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PREFACE.

AWARE that no work is more liable to *general* criticism, than one which affects to treat of the *modus operandi*, adopted in the several Arts and Manufactures dependent on Chemical Science; the Author, at the commencement, perceived that a strict adherence to the accounts, and opinions, even of the most approved Chemical writers, would be far from satisfactory to himself; and would, in many cases, prove delusive to his readers. He likewise foresaw, that, although a general reader might, without farther enquiry, acknowledge, or allow as true, every process and fact comprehended in the following multitudinous assemblage;—some, who should honour his labours by a perusal, might be more fastidious; and, by calling in question the truth of a few particular facts, processes, or opinions; might be apt to pass sentence of condemnation upon the whole. These considerations, conjoined with an ardent desire, which he himself had, of becoming practically acquainted with several of the Chemical Arts, induced him, on many occasions, to seek for information, at its ultimately genuine source; viz. the workshop of the Artisan. The facts thus collected, and others already known, have been blended together: and the Author, in the belief that he has advanced nothing but what is strictly correct, trusts, that as a whole, they will prove useful, not only to the Chemical Student, but also to the Manufacturer, and to the Political Economist.

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Regarding the order of the work, he would say; that notwithstanding the elaborate researches, and ingenious speculations of many learned men in the several departments of Chemical Science; there are very few phenomena so perfectly developed, as to admit of a systematic arrangement of the principles deduced from them: consequently any attempt at forming a system, where the foundation and other parts of the superstructure are incomplete, would prove abortive. It is for this reason, that attempts to systematise Chemistry, have, in every instance, been productive of failure. In the present work, nothing further has been attempted, in the way of arrangement, than a mere generalisation of facts; and those facts, or Experiments, as they are termed, are arranged in classes, either according to their Chemical relation, or according to their nature, and importance in the Arts.

The Author has, now, only to hope that his work may prove as useful, as its execution has been laborious.

London,
July 5, 1821.

INTRODUCTION.

THE Science of Chemistry is the knowledge of the relations of those phenomena, or changes, which take place in the sensible qualities of bodies, as results of the action of one species of matter on another. Thus, the ascension of water from the earth in the form of vapour, by means of the influence of the Sun; the conversion of certain elements of earth and air into the structures of plants by the properties of the organization of these bodies; the formation of coal and other species of bitumen beneath the surface of the globe by the changes which vegetables undergo when their vital properties are lost, and when they have become subservient to other agencies; and the liquefaction of Iron by means of fire, —*all* these are chemical phenomena. On extending the views here pointed out, it will, then, be perceived, that the operations of chemistry are concerned in the greater part of the processes of nature, as well as of those which display the most useful and agreeable results of the art of man.

But Chemistry, like nearly the whole of the other subjects of human skill and industry, was practised as an art, long before any knowledge of its principles was attained; or, in other words, long before it became an object of the regards of science. Men used their arms for the purpose of supplying their wants before they were acquainted with the laws of mechanism; and prompted by the same power, instinct, favoured by the example of others, they exercised many of the useful arts without knowing on what principles they were enabled to attain their ends, at a period very far antecedent to that in which any way of recording their acquirements was known; and more remote, even, than

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that to which the immense grasp of human tradition can extend. Hence, as the late learned Bishop of Landaff observed;—"In vain shall we enquire who invented the first plough, baked the first bread, shaped the first pot, or hollowed the first canoe."

Although, then, the origin of chemistry, as a science, is of but comparatively modern date, and may, indeed, be fixed at so late a period as the sixth or seventh centuries, its operations were resorted to for the purposes of the arts, even at the remotest eras of which any historical accounts now remain, and by nations the least emerged from a state of savage life. The arts of metallurgy, dyeing, and pottery, are mentioned in the earliest literary records, and but very few people have been found so barbarous as not to present some specimens of their productions in them. Several chemical processes of a difficult and abstruse kind, have, indeed, been exercised by nations in times of very remote antiquity, as we learn from the evidence given of the skill of **Tubal Cain**, and the dissolution of the Golden Calf by **Moses**. The art of fermentation, or of making wine, was known in ancient times; as is proved by the intoxication of Noah, there being no inebriating quality in the unfermented juice of the grape. The Egyptians were very early acquainted with the preparation of wine, as is proved by the tradition of Osiris, or Bacchus, having traversed the globe for the purpose of teaching it to all nations: they were also skilled in the manufacturing of metals, in medicinal chemistry, and in the art of embalming dead bodies, long before the time of Moses; as appears from the mention made of Joseph's cup, and from the physicians being ordered to embalm the body of Jacob. They practised also the arts of dyeing, and of making coloured glass, at a very early period; as has been gathered, not only from the testimony of Strabo, but from the relics found with their mummies, and from the glass beads with which these mummies are sometimes studded. The late discoveries of Belzoni, also, prove, that in the preparation of colours, the ancient Egyptians were unrivalled; for, on opening some of the royal tombs which had, for ages, been buried under a great depth of sand, the walls were found to be covered by paintings of the most brilliant and permanent hues: indeed, superior to any thing produced in modern times. The far-famed purple of Tyre is another proof of the perfection to which the art of dyeing had been carried; and their intercourse with the Cornish miners, is sufficient evidence of a solution of tin being used by the Tyrians for that purpose. Wootz, silk-dyeing, porcelain, paper, gun-powder, and other manufactures, in China, and India, must have been discovered, and brought to their present state of perfection at a very early period; for it must be remembered, that in these countries the state of the arts has long been, what it is at the present moment. This we learn from their own writings, and from the well known habits of the Chinese and Indians to produce little or no change in their social and other institutions, after they have once attained the desired end.

That the ancient inhabitants of Italy were acquainted with the arts dependent on chemistry, is proved by the writings of *Pliny* and others; also by the various instruments and articles for domestic use that have been dug up from the ruins of the ancient cities of Herculaneum, and Pompeii*.

The fashion of Aaron's garments clearly indicates that the arts of metallurgy; of dyeing leather red, and linen blue, purple, and scarlet; also of distinguishing, and engraving precious stones, were practised among the Israelites of old. These arts, they had doubtless learned in Egypt, which, at that time, was the emporium of every known science and art.

The European Greeks at the time of the siege of Troy, were not much skilled in the art of chemistry: they do not appear to have been acquainted with the nature of the metallic oxides, or of Iron, or with the means of reducing them; as their spears, darts, and arrows, were headed with *brass*, which, from its inferiority to Iron, would not have been used, for such purposes, had these people been acquainted with the art of forging the latter metal.

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* In prosecuting the excavations of Pompeii, a late traveller, Mr. Williams, informs us, that the streets of the city are becoming daily disencumbered. He entered by the Appian Way through a narrow street of small tombs beautifully executed, with the names of the deceased plain and legible. At the gate was a centry-box, in which the skeleton of a soldier was found with a lamp in his hand, after passing into several streets he entered a coffee-house, marks of the cups being visible on the stone. The streets are lined with public buildings and private houses, most of which have their *original painted decorations fresh and entire*. The pavement of the streets is much worn by *carriage wheels*. A surgeon's house with *chirurgical instruments*; an ironmonger's shop, where was an *anvil* and *hammer*; a sculptor's, and a baker's workshops, both containing the *necessary utensils* for carrying on these trades, were all found in a fine state of preservation.

But, those applications of chemistry to the uses and comforts of man, were processes attained by accident, and transmitted from one generation to another, without any real knowledge of their principles. The division of the people of India into *casts*, and the confinement of certain trades to certain families, exclusively, in Egypt, tended to raise the execution of the mechanic arts in those nations to a certain degree of perfection at a very early period; but those same circumstances also arrested any further improvements in them, at least in all those which are founded on, or perfected by, scientific principles. Various arts or operations executed by the same man, with the liberty of devoting himself to any of them, as he may be prompted by his inclination and talents, tend to invigorate his mind, and oblige him to exert different faculties; and, as he cannot excel in all, he is induced to supply want of skill by ingenious invention: whilst, constant application to a single operation, excludes all thought and invention, and, consequently, all improvement; and hence it is, chiefly, that the arts dependant on chemistry remained stationary when they had arrived at a certain pitch, in the nations above designated.

Amongst the Greeks, the exercise of the mechanic arts was confined to slaves and the very inferior orders of the people. Purely abstract philosophical speculation, politics, the belles lettres, and the arts of war, were the only pursuits which were deemed worthy of the attention of the more intelligent and instructed part of the community: hence it is, that, in regard to chemistry, as well as other branches of physics, their principles, not having been arrived at by a proper mode of enquiry, that of observation and experiment, consisted of a few happy conjectures, enveloped in a multitude of notions, at best erroneous, and often absurd in the highest degree. A favorite notion, in very early ages, was that of the sea being the source of all inorganic, as well as of all organized bodies, which, in conformity with their custom, was enveloped in the fable of the origin and attributes of Venus. At a later epoch, they imagined a certain number of elements to be the bases of all forms of matter, and this dogma of the properties of fire, water, earth, and air, was for a long time prevalent. *Democritus* pursued the true path of science, but he devoted himself chiefly to natural history and the physiology of animals, though he is said to have engaged in chemistry so far as to attempt to imitate natural gems by artificial means. *Aristotle* was too much occupied by metaphysics and natural history to permit him to make much improvement in chemistry, and the notions he did form of the nature of matter in its primitive forms, were never adopted by his cotemporaries or early successors. Some of the conceptions of the early Greeks, were, however, apparently correct, and very surprising, considering the little progress then made in observation and experiment. Thus *Thales* supposed water to be a compound body, formed of a highly inflammable principle and the chief promoter of combustion—an explanation which accords with the information of the present day; that of its being constituted of hydrogen and oxygen gases. He also believed that *fire* was the result of a vivid motion of the atoms of bodies. These are simple demonstrations of their observations and opinions; but, some men have attempted to show that much deep and accurate knowledge in chemistry is veiled in their fables and mythology. *Bacon* conceived that the union of spirit and matter was allegorized in the fable of Proserpine being seized by Pluto, as she was gathering flowers; an allusion, says the author of the *Botanic Garden*, which is rendered more curiously exact by the late discovery, that pure air *(oxygen)* is given out by vegetables, and that in this state it is eagerly absorbed by inflammable bodies. The same elegant poet supposed that the fable of Jupiter and Juno, by whose meeting the vernal showers were said to be produced, was meant to pourtray the production of water, by the combination of its two elements; an opinion, he adds, which is strongly supported by the fact that, in the ancient mythology, the purer air, or *ether*, was always represented by Jupiter, and the inferior, by Juno. These explanations, however, like that of Pan, and some others, by *Bacon*, are, probably, specimens of the ingenuity of the interpretators rather than of the real meaning of the fables: it is certain, at least, that we find no records of such knowledge in plain language, and that as late as the days of *Dioscorides*, operative chemistry was in so rude a state that the best means known of collecting the products of distillation, or sublimation, was that of exposing a fleece of wool, or a sponge, to the volatilized substances.

The knowledge of the Romans, until a somewhat late period, was not more profound. They made excellent *brass* of calamine and copper, but, they had no idea that calamine was an oxide of zinc; and that the combination of the zinc with the copper, was a result of the previous decomposition of the oxide. They supposed that the calamine was a sort of earth which purified the copper in the crucible; that is, extracted from it the grosser parts. Modern chemists are aware that the oxide undergoes decomposition, and that the pure zinc, in combining with the copper, forms a new substance of different properties to either the calamine or the copper.

Such conjectures as those just mentioned, favoured by the ability acquired in the reduction of ores and oxides, by which, what appeared to be merely gross earths were changed into brilliant metals, were but preludes to some wild conceits of fancy, which, in time, spread their influence over the greater part of Europe, and, at length,—after having, for above a thousand years, led multitudes of men to spend their lives, and exhaust princely fortunes, in the vainest attempts that ever became the objects of the ridicule of mankind——laid the basis of modern chemical philosophy. It was of such wild conceits and hallucinations that *alchemy*[*] was constituted, and the object of all the toils of its cultivators was the production of the "*Philosopher's Stone,*" which was to transmute all other metals into gold,[†] to arrest the course of bodily infirmity in man, and to prevent, or remedy all diseases; and it was reported (by *Friar Bacon*, and others,) and vulgarly credited, that *Artephius*, by means of this magic arcanum, had lived to the age of 1025 years.

In the writings of *Athenagoras*, who flourished about the middle of the second century of the Christian era, we find the first traces of this pretended science; and the Roman Emperor *Caligula* is said to have been initiated into its mysteries,[‡] and to have himself made some efforts to obtain gold from the sulphuret of arsenic, which he chose for the subject of his experiments, probably, because of its brilliant and golden hue.

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[*] The term *Alchemy* is Arabic, and formed of *al (the)* and *kemia (excellent)* signifying by a little extension of meaning, the *supreme art*, and hence the appellation, as well as the pursuits of modern *chemistry*, is evidently derived. Before the introduction of this term into Europe by the Saracens, who were the earliest and most zealous cultivators of chemistry, or rather alchemy, in the middle ages, that art had been called, either in relation to some of its particular processes, *chrysopoea*, (fabrication of gold), *argyropœa* (fabrication of silver,) or, generally, *pyrotechnia*, (art of fire) and the *spagyric science*.

[†] The *alchemists* supposed that gold was the metallic element in the state of perfect purity, and that all other metals differed from it only in their being contaminated by *baser* substances.

[‡] The writings of the alchemists consisted for the most part of mysterious expressions, and the names of chemical apparatus were generally conveyed by

The objects of the alchemists, as already stated, were the transmutation of metals into gold, and the discovery of an universal remedy, or *Elixir of Life*; both of which they expected would be accomplished by means of the *Philosopher's Stone*. As they joined enthusiasm with mystery, and promised with boldness what exceeded the steady limits of probability—as they created for their use a symbolic language, and mingled their doctrines with the philosophic and mythologic reveries of all the existing sects and secret societies, they obtained zealous disciples amongst the lovers of the marvellous, whilst they found powerful enemies in all true philosophers. We find alchemists amongst the Manichæans, the Essenians, the Hermits of Thebes, the Cabalists, the Gymnosophists, the Rosicrucians, and the *Illuminati*.* The

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Hieroglyphics, some of which may be seen, at the present day, painted on the bottles on the window-shelves of our chemists. Geber, the Saracen, says, "*bring me the six lepers that I may cleanse them*," by which is implied the conversion of the six *baser* metals, (mercury, copper, tin, lead, iron, and silver,) the only ones then known, into gold. He directs the student to prepare himself by suitable acts of piety and charity, which, if earnestly carried on, may, after due time, enable him, in the language of his translator, Dr. Salmon, "to change argent vive into an infinite solific and lunific, without the help of any thing more than its multiplication." Geber, who lived about the seventh century, appears, however, to have invented much useful apparatus: convenient alembics, crucibles, and furnaces, are described in his works.

* We find the names of Pope John the XIIth, a cardinal, Nicholas of Cusa, three bishops, two abbots, four rich canons, a multitude of monks, cordeliers, Jacobins, Jesuits, Benedictines, and Capuchines, Friar Bacon, Albert the Great, Saint Thomas, Arnold, Raymund Lully, Ripley, Basil Valentine, Father Kircher, Salmon, Digby, Kelly, and Dee, amongst those of the alchemists; and even Sir *Theodore Mayerne*, (the *Doctor Caius* of Shakespeare,) though he lived at so late a period, may be considered a sectary of this philosophy.

Some of those were, undoubtedly, zealous believers in the possibility of transmutation, and the other effects of the *Philosopher's Stone*; but several of them appear to have been artful men who were disposed to dupe mankind for the advancement of their own fame and interests. Brucker, on speaking of Raymund Lully, says, "he was more ingenious than honest." Villa-Nova was a famous *prophet*, as well as an alchemist; and he predicted that the world would come to an end in the year 1376. He was himself shipwrecked on the coast of Genoa, in 1313. Evelyn, in his Diary, alluding to Sir Kenelm Digby, says, "he gave me a certain powder, with which he affirmed that he had fixed mercury before the late king. He advised me to try and digest a little better, and gave me a water which he said was only rain-water, of the autumnal equinox, exceedingly rectified, and very volatile; it had a taste of strong vitriolic, and smelt like aquafortis. He intended it for a dissolvent of a calx of gold; *but the truth is, Sir Kenelm was an arrant mountebank*." The believers in the *Philosopher's Stone* readily gave credit to every tale tending to favour their cause, and did not jugglers of India, Asia, and Europe, were associated for many ages with the pretended possessors of the philosopher's stone; and many princes, in the efforts they made to destroy them, were, perhaps, prompted by alarm for their own safety, rather than by an abhorrence of such errors. Some, however, were actuated by a real love for true philosophy. *Dioclesian* ordered all the writings relating to the *great work* (as it was termed) to be destroyed; and since the adoption of Christianity, popes and kings have often fulminated their anathemas and proclaimed their decrees against the alchemists, without, however, doing any thing towards curing them of their folly; for when an enthusiastic passion gives energy to the opinions of men, all authority of power, alone, is opposed to them in vain; nothing, but reason and truth, is capable of assuming any influence over them.

The credulous part of the people, in what are called the middle ages, seem to have generally believed that the secret of the philosopher's stone was possessed by some few, who were waiting only for a favourable epoch for manifesting their power in all its mightiness. *Arnold*, of Villa-Nova, was said to have converted iron into gold, at Rome; and *Raymund Lully* to have effected a similar operation before *Edward* the First, in London, of which it was said that gold nobles were made. The notions of the Rosicrucians were then very prevalent; and those which embraced the ideas of gnomes and sylphs, and other spirits who governed the elements, being capable of being rendered subservient to man, contributed much to favour the visions of alchemy.

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hesitate to interpret every thing as it suited their own purposes. Thus, Dr. Salmon, (whose name is mentioned above, and who lived towards the latter end of the seventeenth century,) on speaking of Nicholas Flammel, who suddenly, as it is said, became very rich, and who founded several hospitals, repaired churches, and endowed charitable institutions, says, "Flammel was originally a poor scrivener, yet left so great monuments behind him as must convince the most incredulous that he knew the secret, and performed such mighty works at his own proper cost and charges, as the most opulent prince in Europe can never do the like. I know a gentleman who went to view those mighty buildings and their records. The archives and governors of those places, he told me, own the matter of fact, but deny the means, saying, that Flammel was a very pious man, and went a pilgrimage to St. James of Gallicia, for a reward of which piety the holy saint bestowed that vast treasure upon him by way of miracle, *thereby denying the power of art by which it was certainly effected*, to establish a miracle performed by the Romish saint." Flammel was also celebrated for his hieroglyphics, of which *fac-similies* are given in a tract published by Salmon: they would furnish some very appropriate pictures for *Moore's Almanack*.

About the beginning of the thirteenth century, many useful, and highly valuable discoveries began, however, to be made known. *Bacon* happily described the alchemists as similar to those husbandmen, who in searching for a treasure supposed to be hidden in their land, by turning up and pulverizing the soil, rendered it fertile. In searching for improbabilities they sometimes discovered realities.* The

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* The following curious anecdote of the *mania* with which alchemy was followed, even at a late period, and of one of the beneficial consequences which resulted from a pursuit of this phantom, will be amusing to the reader. The valuable discovery made in the case we are about to relate, was that of DRESDEN CHINA.

In the beginning of the eighteenth century, there lived in the territories of the Elector of Saxony, a man of great learning, and most indefatigable industry in the hermetic (chemical) science; and being in expectation of success in his designs, the fear of persecution induced him to take refuge in a place where, not being known, he might live unsuspected; his habitation was fixed in a chemist's house, that the use of such implements as were necessary might not appear extraordinary. In this house he died, and as some sort of acknowledgment for the kindness of his host, he presented him, on his death-bed, with a small quantity of chemical preparations, which, he told him, had full power to effect the transmutation of metals; at the same time giving him directions for using of them, yet concealing the matter and method by which he had acquired this valuable secret.

Whether the chemist had, amongst the effects of the deceased, met with some other secret more practicable, and profitable, is not known; but he suddenly grew rich, and having been weak enough to suffer the circumstances of the alchymist to transpire, it was quickly rumoured abroad, that he was possessed of a quantity of the *powder of projection*, which enabled him to make as much gold as he wished.

This report soon reached the Elector's ear, who immediately sent for him, and told him that if he was possessed of such a secret, the exertion of it was due to his sovereign, and that what gold he made must be for the use of his master, out of which he should be nobly provided for. In vain was it to deny the fact; the Elector told him, that death, and the confiscation of all his effects to government, would be the consequence of his persisting in a refusal.

Willing to sacrifice part of his fortune to preserve life, he assured his highness that he had but a very small quantity of the powder left, but that should be devoted to his service.

Accordingly, he was confined in a castle, with a proper allowance, and there left to make gold for his sovereign. Masses of that metal were from time to time delivered by him to persons commissioned to receive them: until at length he was obliged to declare that he had used the whole of the powder which had been given to him, and must therefore beg leave to desist from any future pretensions relative to that arcanum. This answer, however, was not satisfactory to the prince, who insisted that he must be acquainted with the secret, and menaced him with death, unless he pursued the task that had been imposed on him. The poor man, terrified, entreated as his last resource a respite of twelve months, to enable him to find out what it was, after which time, in case of failure, he should be ready to submit to his sentence. This, with some difficulty, was granted him; and he was confined, with a close guard, to prevent escape, yet amply furnished with all necessaries and conveniences of most successful amongst them, at the commencement of this epoch, were *Albert*, in Germany, and *Roger* (commonly known by his appellation of *Friar*) *Bacon*, in England: though these men seem not to have been wholly led away by the visions of their contemporaries, but to have cultivated science in many respects in the most laudable manner. They, especially the latter, seem to have as far exceeded the common standard of learning in the age in which they lived, as any philosophers who have appeared in any country, either before their time, or since. But, within a hundred and twenty years from the death of *Friar Bacon*, the nobility and gentry of England had become so infatuated with the notions of alchemy, and had wasted so much of their property in search of the philosopher's stone, as to render the interposition of government necessary to restrain their folly. The following act of parliament, (which Lord *Coke* called the shortest he ever met with,) was passed 5th of *Henry* IV. "None from henceforth shall use to multiply gold or silver, or use the craft of multiplication; and if any the same do, he shall incur the pain of felony." It has been suggested, that the reason of passing this act, was not an apprehension lest men should ruin their fortunes by endeavouring to make gold, but a jealousy lest government should be above asking aid of the subject. This act, whatever might be the occasion of passing it, though it gave some obstruction to the public exercise of alchemy, yet it did not cure the disposition for it in individuals, nor remove the general credulity; for in the 35th of *Henry* VI., letters-patent were granted to several people, by which they were permitted to investigate an universal medicine, and to perform the transmutation of

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life, and provided with all materials and utensils that could forward his researches.

At length the year expired, and the philosopher's stone no nearer perfection than at the beginning of it. But, in the process of his enquiry after it, amidst the hopeless trials he had made by "fusion, calcination, vitrification, separation, cribration, ablution, edulcoration, despumation, limation, pulverization, granulation, putrefaction, maceration, fumigation, cohobation, precipitation, amalgamation, distillation, rectification, sublimation, rapidification, extinction, reverberation, fulmination, extraction, digestion, circulation, consolidation, spiritualization," and other methods of almost every thing he could think of; at the close of one process, a substance almost as valuable as gold glowed in his crucibles; and this was no other than the composition of the highly esteemed DRESDEN CHINA; the importance of which was so evident to his electoral highness, that he not only pardoned the inventor, but also bestowed on him a very large estate, and raised him to the rank of nobility.

metals into real gold and silver, with a non-obstante of the forementioned statute, which remained in full force till the year 1689, when being conceived to operate to the discouragement of the melting and refining of metals, it was formally repealed.*

The beginning of the sixteenth century was remarkable for a great revolution produced in the European practice of physic, by means of chemistry; for, *Paracelsus*, famous for curing syphilis, the leprosy, and other virulent disorders, by means of mercurial and antimonial preparations, wholly rejected the Galenical pharmacy, and substituted the Chemical in its stead. He had a professor's chair given him by the magistracy of Basil, and was the first who read public lectures in medicine and chemistry, and subjected animal and vegetable, as well as mineral subs ances, to examination by fire.

So great a genius as *Paracelsus*, could not fail of becoming alike the subject of the extremes of panegyric and satire. He has accordingly been esteemed by some, as a second *Esculapius;* others have thought that he was possessed of more impudence than merit, and that his reputation was more owing to the brutal singularity of his conduct, than to the cures he performed. He treated the physicians of his time with the most illiberal insolence, telling them, "that the very down of his bald pate had more knowledge than all their writers; the buckles of his shoes more learning than *Galen* or *Avicenna;* and his beard more experience than all their universities." He revived the extravagant doctrine of *Raymund Lully*, concerning an universal medicine, and untimely sunk into his grave at the age of forty-seven, whilst he boasted himself, to be in possession of secrets, able to prolong the present period of human life to that of the antediluvians!

But in whatever estimation the merit of *Paracelsus*, as a chemist, may be held; certain it is, that his fame excited the envy of some, the emulation of others, and the industry of all. Those who attacked, and those who defended his principles, equally promoted the knowledge of chemistry; which from his time, by attracting the notice of physicians, began, every where, to be systematically treated, and more generally understood.

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* Boyle is said by his interest to have procured the repeal of this singular statute, and to have been induced thereto, in consequence of being persuaded of the possibility of the transmutation of metals into gold.

Soon after the death of *Paracelsus*, which happened in the year 1541, the arts of mining and fluxing metals, received great illustration from the works of *Georgius Agricola*, a German physician.

Lazarus Erckern (assay-master-general of the empire of Germany) followed *Agricola* in the same pursuit. His works were first published at Prague, in 1574, and an English translation of them by Sir *John Pettus*, came out at London, in 1683. Several others have been published, chiefly in Germany, upon the same subject, since their time. Germany, indeed, has for a long time been the great school of metallurgy for the rest of Europe; and the British owe the present flourishing condition of their mines, to the wise policy of Queen *Elizabeth*, in granting great privileges to *Daniel Houghsetter*, *Christopher Schutz*, and other Germans, whom she had invited into England, in order to instruct her subjects in the art of metallurgy.

It was not, however, till towards the middle of the last century, that chemistry began to be cultivated in a philosophical manner. So early as the year 1645, several ingenious persons in London, had formed themselves into a society, and held weekly meetings, in which they treated of *the new*, or *experimental philosophy*. These meetings were continued till the establishment of the Royal Society, in 1662; and before that time, similar meetings were held in Oxford, and those studies brought into repute in that university. *Boyle* was a principal person in the Oxford meetings; he published at that place, his Sceptical Chemist, in 1661, and by his various writings and experiments, greatly contributed to introduce into England a taste for rational chemistry.

Next to *Boyle*, or perhaps before him, as a chemist, stands his contemporary, the unfortunate *Beccher*, whose *Physica Subterranea*, justly entitled, *opus sine pari*, was first published in 1669. He resided some time before his death in Cornwall, which he calls the *mineral school*, owning that, from a teacher, he was there become a *learner*. He was the author of many improvements in the manner of working mines, and of fluxing metals; in particular, he introduced into Cornwall, the method of fluxing Tin by the flame of pit-coal, instead of wood or charcoal. This great man was invited to Vienna, where he contributed to the establishment of several manufactures, a chamber of commerce, and an India company; but the jealousy of the ministry finally accomplished both his disgrace and his ruin. He was not less unfortunate at Mentz, Munich, and Wurtzburgh, which determined him to go to Haerlem, where he invented a machine whereby a great quantity of silk might be worked in a little time, and with few hands. New disgraces and misfortunes however awaited him, and he was obliged to retire to England. He died in London, in 1682, at the age of fifty-seven. Stahl, the Prussian, followed the footsteps of the illustrious Beccher. It was the opinion of these two philosophers, that fire enters into the composition of all inflammable bodies, and into metals, and most minerals; and in that condensed state it was called phlogiston, (latent fire,) to distinguish it from fire in its free state. They tell us that fire (phlogiston) is actually a material body, and liable to be modified by the influence of circumstances. In bodies liable to burn, it exists in a latent state; place them in circumstances in which combustion is produced, you then will behold it, perceive it operate, and feel its influence.

Van Helmont was accounted a magician, and was tortured by the Inquisition. It is said of this great man, that he discovered, in the middle of the last century, many of those important facts which adorn the writings of Priestley and Lavoisier. He first gave the name of *gas* to those vapours which resemble the air we breathe; and he illustrated his theory by some phenomena of the animal economy, such as the suffocation of workmen in mines, the accidents occasioned by the vapour of charcoal, and that destructive atmosphere which is breathed in cellars where liquors are in a state of fermentation. He accounts for several diseases upon this principle; and ascribes the propagation of epidemical disorders to noxious vapours with which the air is infected.

Had the progress of chemical knowledge stopped here, it would have been of little importance to the world, as the facts which were already discovered, were so distorted by every new theorist, that they only tended to render the study unsatisfactory and obscure; but Lord *Bacon*, whose comprehensive mind saw the immense advantages that might result to the world in general, from this branch of philosophy, advised the collecting of facts, and the comparing of these deliberately, in order to discover the causes and circumstances upon which they depended. "Thus only," says he, "can a satisfactory system be produced. If experiments are not directed by theory, they may be a blind feeling; but theory without experiment is deceitful and uncertain." This sagacious philosopher attained his object; for he soon completely banished that dark and abstruse philosophy which was built upon conjecture alone.

On the very day that Lord Bacon died, the famous Boyle was born. The opulence of his circumstances enabled him to pursue with ardour the path which Bacon recommended, and he was amply qualified for the task. He was possessed of a penetration and ingenuity of mind. which, in experimental philosophy, serve to point out the shortest and most simple, as well as the most useful experiments; and to deduce important truths from apparently the simplest and most insignificant facts.

The progress of useful chemistry was, however, much impeded about this period, in consequence of its cultivators being, to a great extent, physicians; who became infatuated with the notion that this science was to furnish the means of explaining all the functions of the human body, as well as to account for the origin of disease and the operations of medicines. These notions had originated with Paracelsus, and were soon favoured by Du Chesne, Mayerne, Mynsicht, and De la Boe. The human body, according to the last named physician, was a chemical apparatus, where the heart is excited to action by the fermentation of the blood. From the food, digested in the stomach, there arise vapours distilled into the brain, which sends spirits to all the other organs of the body. Diseases depend on fermentations which corrupt the humours. From the fluids, in a state of effervescence, precipitations, dissolutions, and despumations take place, similar to those in a barrel of wine. Our great *Mayow*, even, who had some glimpse of the modern discoveries respecting oxygen gas, supposed that the inflammable particles of the air insinuated themselves into the blood, and produced a sort of vital combustion with the sulphureous elements of that fluid. *Willis* framed a physiological hypothesis, in which he supposed that a continual extrication of igneous vital spirits was going on in the brain:—the blood he considered to ferment like beer; spasms, he thought, arose from an explosion of salt and sulphur in the animal spirit; and scurvy, from a state of the blood similar to faded musty wine. It seems, that, in this instance, as well as in every other branch of philosophy, the human mind must run through all the devious tracks in the labyrinth of error, before it could take the single path which leads to truth.

Many men, however, rose up towards the termination of the 17th century, who made a multitude of discoveries in chemistry that tended, in a remarkable degree, to the improvement of several useful arts.

Lemery's very accurate course of practical chemistry, appeared in 1675. Glauber's works had been published at different times, from 1651 to 1661, when his tract, intitled Philosophical Furnaces, came out at Amsterdam. Kunckel died in Sweden, in 1702; he had practised chemistry for above 50 years. Having had the superintendency of several glass-houses, he had an excellent opportunity of making many experiments in that way; and enamellers, and makers of artificial gems, say that they can depend more on the processes and observations of Kunckel, than upon those of any other author upon the same subjects. At this period the chemical labours of these, and other great men, were greatly forwarded by the establishment of societies (with the great Newton at their head,) for the encouragement of Natural Philosophy, in various parts of Europe. These societies, by a publication of reports and transactions, greatly accelerated the science of chemistry. The labours of Newman, Neoffruau, Inucke, Geoffroy, Boerhaave, Black, and many others, with the mathematical precision inculcated by the example of Bergman, tended greatly, at this period, to the same end.

The academician Del Cimarto made many interesting experiments, and some curious discoveries respecting the laws of the phenomena of heat. *Homberg* discovered the boracic acid and the pyrophorus. Geoffroy instituted a more simple mode of preparing and compounding medicines, which has been of great service to the healing art. Hales made some highly ingenious experiments for analysing the constituents of the air; and Black, soon afterwards, discovered the carbonic acid gas, the qualities of which were more fully ascertained by Macbride. The next step, in this course was made by Rutherford, in the discovery of nitrogen or azote, another constituent of the air; when the immortal Priestley arose, who, with an intuitive genius, entered upon his philosophic career, and proceeded with such unexampled success, that he excited the admiration and surprise of the learned world. It is impossible to do justice to his numerous and useful discoveries. To him we are indebted for the new modelling of the whole science of chemistry, by the discovery of oxygen, which he denominated dephlogisticated air. It is a curious fact, that this discovery was also at the same time made (though by a different process,) by the foreign chemist, Scheele. Among Priestley's numerous discoveries, the most singular, perhaps, was that of plants emitting vital air and absorbing fixed air. After this interesting and extraordinary fact was communicated to the Royal Society, the president, Sir John Pringle, addressed Dr. Priestley as follows:—"From your discoveries, we are assured that no vegetable grows in vain; but that, from the oak in the forest to the grass in the field, every individual plant is of service to mankind; if not always distinguished by some medicinal virtue, yet making a part of the whole, which cleanses and purifies our atmosphere. In this, the fragrant rose-tree and deadly nightshade co-operate: nor is the herbage, nor woods that flourish in the most remote and unpeopled regions, unprofitable to us, nor are we to them, considering how constantly the winds convey to them the fixed air issuing from our lungs, while they send out vital air for us."

What is particularly remarkable in the character of Priestley, and which, from its intimate relation to the improvement of science, must be here noticed, is the extreme modesty with which he always spoke of his discoveries, and, as it indeed seemed, the surprise with which he himself regarded the importance attributed to their results. Others have carefully concealed the agency of chance in their acquirements; Priestley seems to have wished to attribute every thing to it. He remarks, with singular candour, how often he had thus been favoured without perceiving it, how many times he possessed new substances without distinguishing them; and he never dissimulates the erroneous views which sometimes directed him, and which he only recognised by experience. His great chemical work is, indeed, not a series of theorems, deduced one from the other; it is a simple record of his thoughts in all the disorder of their succession. We perceive in it a man, as it were, groping his way along in a dark night; catching the slightest glimpses of light; sometimes led astray by false meteors; but arriving at last at a rich and brilliant region. Such is the course even of men of genius. Newton had already disclosed the secret; for, on being asked how he had arrived at his great discoveries, he replied, by long, assiduous, and repeated reflection.

The next highly important discovery, was that of the properties of hydrogen, and the composition of water, by *Cavendish*. This philosopher, who, from the time when he commenced his scientific career, is said to have never wasted a minute of his life, or even uttered an unnecessary word,* had, as early as the year 1766, and previously to the more minute and accurate discoveries of Priestley, sustained, in a paper read to the Royal Society, the following propositions: *The air is not an element; there exists several species of airs essentially different;* in which he shewed the chief properties and qualities of what was then called *fixed air*. His memoirs may, indeed, be considered as the basis of the researches of Priestley. After this, the next very important discovery of Cavendish was that of the composition of the nitric acid, of which chemists had previously had only some vague conceptions. It was at this time that Berthollet was making his discoveries of the composition of ammonia, shewing it to be formed of hydrogen and azote. The whole of the discoveries of Cavendish are described in a few pages, but we must not measure their importance by the space their history occupies. To unravel the knot which involves so many complicated phenomena, to pursue the same principle through so many devious tracts and changes, and especially, to develope it so clearly; that what had for ages escaped the most able enquirers, becomes in a few minutes evident to the world, can only have been the results of meditation not merely the best directed, but also the most assiduous.

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* His servants learned to understand by his signs what he wanted, and, as he required but little of them, this sort of dictionary was not a very long one. He had but one suit of clothes at a time, which was renewed at fixed periods, and was always of the same cloth and colour. When he was disposed to ride, he expected to find his boots always in the same place, and his whip in one of them, which was always to be the same. He had been left a large fortune by an uncle but was so careless about his property, that his banker came one day to tell him that above eighty thousand pounds had accumulated in his hands, and that he could not, without shame, keep so large a sum as a simple deposit, without paying interest for it. He formed a large library, and a very rich cabinet of natural history, for the use of the public; from which he himself borrowed books, &c. with the same formalities as strangers.

Cavendish was, indeed, a living proof of the adage of one of his most illustrious contemporaries,—that genius is nothing more than a very great aptitude to patience.—An adage rigorously true, if it be added that it is necessary that this patience be that of a man of talent.

Contemporary with Priestley, flourished that illustrious votary of chemical science,—the ill-fated Lavoisier, who reformed the chemical nomenclature, which before that time was in a most confused state. His chief discoveries and contributions to the science of chemistry, consist in his proving that what had been called *fixed air*, consists of oxygen and carbon; and by demonstrating the similarity of the results of the combustion of the diamond and charcoal, he showed the probability of the identity of those two apparently dissimilar bodies. He ascertained the exact proportion of the constituents of the atmosphere, and he was the founder of the theories of combustion and of acidity, which were generally adopted until some later discoveries showed their insufficiency and partial incorrectness. It does not come within our province to mention, in this place, the applications of those and other discoveries, already enumerated, to the useful arts: they will be shown at length in the body of the following work, with others of later origin.

Fourcroy also lived at the same period, and though the high reputation which this chemist attained, depended chiefly on his brilliant talents as a public lecturer, he must also be mentioned amongst the discoverers of interesting facts in this science. Cavendish had shewn, that the combustion of hydrogen gas produced water; but the water obtained by his process was always more or less mingled with nitric acid, which furnished the opposers to the theory of Cavendish, with an objection which they thought decisive. Fourcroy obtained pure water, by operating in a slower manner, and he shewed that the acid resulted from some particles of azote, (always mingled with the oxygen,) which burns with the hydrogen, when the combustion is too rapid. He also discovered several compounds which detonate by simple percussion, all of which are composed of oxygenated muriatic acid, (according to the older nomenclature,) and some combustible body.

Profiting by the discoveries of Priestley, in respect to the gases, Fourcroy was enabled to give new precision and exactness to the analysis of mineral waters.—He was engaged in experiments with platinum, at the same time with Mr. Tennant and Dr. Wollaston, and made some discoveries which were common to them. He was especially skilful in the analysis of metals, and when the property of the churches in France, was destroyed at the Revolution, he shewed how the copper of the bells might be separated from the tin; and thus, an alloy of use only for the specific purpose to which it had been applied, was rendered profitable to artizans. He was also the founder of the modern and improved mode of analysing vegetable substances, and was one of the first who discovered in them the existence of albumen; and pointed out how useful chemistry might be to politicians, by shewing the relative nutritive properties of different vegetables. His application of chemical analysis to animal matters, was not less exact and important, by the results to which it conducted; this was especially the case in regard to the more accurate knowledge of the composition of urinary calculi. One of the most curious facts which he discovered, was presented to him in 1786, at the burial-ground *des Innocens*, at Paris. The French government having resolved to suppress this source of infection, which, for many ages, received the bodies from the most closely peopled part of the capital, ordered, not only, that no burials should henceforth be made there, but that the bodies already deposited there, should be transferred elsewhere. On proceeding to effect this removal, a great part of the bodies was found transformed into a white, fatty, and combustible, substance, similar, in its essential properties, to *spermaceti*. A thorough investigation of the circumstances, and the comparison of some analogous facts, shewed that this change takes place in all animal matters, preserved from the contact of the air, in damp places. This discovery has already been taken advantage of, by artificially converting animal matters not adapted for food, into a substance fit for excellent candles; and it shews that there is none of our observations, however in appearance trivial, that may not become useful to society.

At a somewhat later period flourished Morveau, the great purifier of hospitals, ships, and prisons; Chaptal, the promoter and the historian of the Arts in France; Lord Stanhope, the revivor of Stereotype Printing, the discoverer of a metallic alloy adapted for casting Plates for this purpose, and of many other useful improvements in the

Arts; Tennant, the discoverer of the true nature of diamond; Wedgewood, the inventor and manufacturer of English porcelain; Dr. Franklin, the discoverer of the identity of lightning with the electric fluid; and Dr. Watson, the friend of science, and the historian of the Arts in England.

Chemistry was now in a rapidly improving condition. Throughout Britain, and the continent of Europe, this science was studied with avidity by numberless votaries, who were every day starting into existence. In France, the revolution spurred thousands on to chemical enterprise; and the energies of that nation were amply remunerated by plentiful stores of sugar from beet-root; of salt-petre from common dung-hills; by the culture of woad, and by the produce and manufacture of almost every article of luxury and necessity, with which they were formerly supplied from abroad.*

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* In Nicholson's translation of Fourcroy's System of Chemical Knowledge, vol. I. page 24, we find the following interesting passage:—"The annals of the French revolution will tell to the world how much the war of liberty is indebted to the inventions and to the resources of chemistry. France, pressed by powerful and numerous enemies, blockaded at sea by their colossal fleets, deprived of the products which commerce afforded her in ordinary times, was destitute of saltpetre, of copper, of steel, of mercury, of sulphur, of leather, and of a number of other objects more or less necessary to the wants and the support of its inhabitants. The arms of her numerous and valiant defenders could not effect this, and her soldiers themselves were destitute of arms to render them formidable to her enemies. Her soil, so rich in productions, did not seem calculated to afford what her commercial industry had till then obtained in foreign countries. Without the genius of chemical science, she would have been threatened with an absolute want of the means of defence. An active administration, accustomed to overcome every resistance, because it felt all the power of the French people, and because it knew how to employ the whole of their force, conceived the hope of finding in chemistry what the ordinary course of manufactories could not furnish, and what interrupted commerce refused. It called together the most enlightened chemists, united them, and explained to them, its pressing and extensive wants, the confidence which it placed in their knowledge, and the assistance it demanded from them. Its expectation was not disappointed: its hopes were realized even beyond the point to which they were directed! We have seen all France informed by this assembly of learned men, of the immense quantity of saltpetre which nature had deposited in her bosom; we have seen the whole state converted into saltpetre works, all the citizens occupied and emulating each other in the search for, and extraction of this salt. Speedily the national manufactories, the arsenals, the ports, the strong places, and the camps, became so fully supplied by this immense formation, beyond every measure and proportion till then known, that after many years of dreadful war this vast provision was far from being exhausted; and the movement communicated by this vast enterprise, may indeed be retarded, but can never be entirely stopped. *This famous*

The French, and other chemists of the present period are so numerous; and their number is, daily, so much on the increase, that our limits are too small even for their names. Still, we must find room for those of Rumford, Cadet, Vauquelin, Parmentier, Berthollet, Guadet, Arago, Biot, Thenard, Caventou, and Gay Lussac, the elaborate analytical researches of every one of whom, have tended so much to the advancement of natural science. In looking towards Russia, we cannot forget the name of Kirchoff, the converter of starch and other substances into sugar; nor when turning towards Sweden, that of Berzelius, the chemical meteor of the north, who has thrown so brilliant a light over the whole hemisphere of science. Volta, Galvani and Morrichini, in Italy, have made discoveries which endear their names to their fellow labourers in the field of philosophy: whilst Hare, and others in America, have proved to Europeans, that when the tree of science is transplanted across the Atlantic; it is capable of taking as firm a root in the gardens of Columbia, and of furnishing fruit in as great luxuriance, as when it grew on its native soil.

But it was reserved for the British chemists to make those researches which have tended, in the greatest degree, to promote the happiness and comfort of mankind. The energies given to the steam-engine, by Watt and Bolton, have created a great revolution in the quantity of manufactures produced, and of minerals dug from the bowels of the earth in a given period of time. The illumination by gas-lamps has given a new character to our street and towns.

In enumerating the chemists of Britain we are equally limited. The names of Higgins, Henry, Murray, Thomson, Leslie, Brewster, Jameson, Ure, Nicholson, Parkes, Brande,

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instance never will be lost. Chemistry has proved that after some years of repose, the earth of cow-houses, of aviaries, of stables, of cellars, of caves, and of almost all the places inhabited by or serving as receptacles for storing animal or vegetable substances, becomes again charged with saltpetre, and that a new extraction of that salt made with activity similar to that of the former, and with more regularity and method than that could be in the difficult times in which it took place, will again afford a greater quantity of that salt than was at first obtained. Here then is an inexhaustible supply discovered by chemistry of a substance most useful to national defence, and of the highest advantage to a number of works and manufactories. The same men taught the method of purifying this natural product in a few hours, instead of more than a month, which it formerly required, and by that means to render it proper for the composition of gunpowder, of which the fabrication has become at once more speedy and less dangerous."

Wollaston, Allen, Marcet, Pepys, Children, Dalton, Kirwan, and the three Davys, are familiar to every one; but were it not for the truly splendid discoveries of the English father of chemistry, Sir Humphrey Davy, president of the Royal Society, this science would have made but a comparatively unimportant progress in this country. This philosopher's decomposition of the alkalies and earths; and his discoveries of substances new to chemists, and to the rest of the world, have fixed on him the admiration of every man of science; whilst his construction of the safety-lamp, on principles discovered by his own mental exertions, has thrown around him the halo of scientific philanthropy, revered in grateful silence by the miner whom he has rescued from the jaws of untimely death.

The establishment of the Royal Institution, and other chemical, mineralogical, and geological schools throughout Britain, has tended greatly to the diffusion of science; so much, indeed, are these institutions appreciated, that chemistry is now becoming a common branch of education. It is no longer considered merely in a medical point of view, nor restricted to some fruitless efforts upon metals; it no longer attempts to impose upon the credulity of the ignorant, nor affects to astonish the simplicity of the vulgar, by its wonders; but is content with explaining the phenomena of nature upon the principles of sound philosophy. It has shaken off the opprobrium which had been thrown upon it, from the unintelligible jargon of the alchemists, by revealing all its secrets, in a language as clear and as common as the nature of its subjects and operations will admit.

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ONE THOUSAND
EXPERIMENTS
IN
CHEMISTRY AND THE USEFUL ARTS.

CHAPTER I.

PREPARATION OF METALLIC ALLOYS.

General Observations.

WHEN a metal combines chemically with another metal, so as to alter its properties, the compound is called an Alloy. Alloys, generally, possess properties very different from those of the metals which compose them. In some instances, their specific gravity is greater: in others, they are more fusible, more ductile and elastic, or they vary in colour or durability. An Alloy, too, is often more sonorous than its component metals in a separate state.

EXPERIMENT

Brass.

Put 4½ ounces[*] of Copper into a crucible, expose it to heat in a furnace, and when perfectly fused, add an ounce and a half of Zinc. The metals will combine, forming that generally used Alloy called Brass. Mould it into a bar, or any other shape.

Observations. This alloy, it is well known, resists the action of the atmosphere better than pure copper, and is therefore employed for many useful purposes, as mathematical and chemical instruments, &c. which, if formed of copper only, could never be kept free from tarnishing.

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[*] It is necessary to observe, that the quantities prescribed throughout this chapter, are such as are calculated for mere experiment. When the compounds here detailed are prepared on a large scale, the quantities of course vary in degree, although proportionally they are still the same.

For brass which is to be cast into plates, from which pans and kettles are to be made, and wire is to be drawn; braziers use calamine of the finest sort instead of pure zinc, and in a greater proportion than when common brass is made;—generally fifty-six pounds of calamine to thirty-four of copper. Old brass which has been frequently exposed to the action of fire, when mixed with the copper and calamine, renders the brass far more ductile, and fitter for the making of fine wire, than it would be without it; but the German brass, particularly that of Nuremberg, is, when drawn into wire, said to be preferable to any made in England for the strings of musical instruments.

II.

PINCHBECK.

Put into a crucible five ounces of pure Copper; when it is in a state of fusion, add an ounce of Zinc. These metals combine, forming an Alloy, called Pinchbeck, not unlike Jewellers' gold: pour it into a mould of any shape. This Alloy is used for inferior jewellery.

Observation. Some use only half this quantity of zinc, in which proportion the alloy is more easily worked, especially in the making of jewellery.

III.

PRINCE'S METAL.

Melt in a crucible 4 ounces of Copper, and when fused, add 2 ounces of Zinc: they will combine and form a very beautiful and useful Alloy called Prince Rupert's metal.

IV.

BRONZE.

Melt in a clean crucible 7 ounces of pure Copper: when fused, throw into it 3 ounces of Zinc, and 2 ounces of Tin. These metals will combine, forming Bronze, an Alloy which, from the exactness of the impression which it takes from a mould, has, in ancient and modern times, been generally used in the formation of Busts, Medals and Statues.

V.

ALLOY FOR THE SPECULA OF TELESCOPES.

Melt 7 ounces of Copper, and, when fused, add 3 ounces of Zinc and 4 ounces of Tin. These metals will combine to form a beautiful Alloy of great lustre, and of a light yellow colour, fitted to be made into specula for telescopes. Mr. Mudge used only Copper and grain Tin, in the proportion of 2 pounds to 14 ounces and a half.

Observations.—There is an alloy of late discovery, called Petit-or, which has been extensively used in the arts as a substitute for gold. It possesses in a certain degree all the qualities of gold except its weight. It takes a most beautiful polish, is less liable to be scratched than gold, and though very ductile, is capable of being rendered extremely strong and elastic: It is peculiarly adapted for watch cases, snuff boxes, and all the variety of trinkets for which gold is employed. A Mr. Mill, too, has discovered the proportions of an alloy which promises to be of considerable use. It resembles in colour, and is nearly as heavy as jewellers' gold. It is malleable, does not easily tarnish; is very hard and sonorous, but requires care in working. The price being only about 4 shillings an ounce, it will no doubt come into general use as a substitute for gold, more particularly as it is susceptible of an exquisite polish. The inventor has termed it "*Aurum Millium.*"

VI.

GUN-METAL.

Melt together 9 parts of Copper and one part of Tin: the compound will be that used in the manufacture of small and great brass guns, swivels, &c.

Observations. The pieces of ordnance used by the besiegers at the battle of Prague, were actually melted by the frequency of the firing; the mixture of which they were made contained a large portion of lead; it would have been less prone to melt, and consequently preferable, had it contained none. A mixture of copper and tin is preferred to pure copper, not only for the casting of cannon, but of statues, &c.: for, pure copper, in running through the various parts of the mould, would lose so much of its heat, as to *set*, or become solid too soon.

VII.

BEAUTIFUL ALLOY OF ANTIMONY AND COPPER.

Put into a clean crucible an ounce of Copper, and an ounce of Antimony; fuse them by a strong heat, and pour the Alloy into a mould. The compound will be very hard, and of a beautiful violet hue.

Observation. This alloy has not yet been applied to any useful purposes, but its excellent qualities, independent of its colour, entitle it to consideration.

VIII.

BELL-METAL.

Melt together 6 parts of Copper and 2 of Tin:—the composition will be that known by the name of Bell-Metal. These proportions are the most approved for Bells throughout Europe, and in China.

Observations. In the union of the two metals above mentioned, the combination is so complete, that the specific gravity of the alloy is greater than that of the two metals uncombined; thus 2 cubic inches of bell-metal will weigh heavier than two cubic inches of tin or copper separately. Another remarkable circumstance in the union of these metals in the above proportions, is, that although only ¼ of the tin be used, still it has so much influence over the copper as entirely to destroy its colour, and substitute one nearly like its own, instead. Some bells are made in the proportion of 10 parts of copper to 2 of tin. It may be in general observed, that a less proportion of tin is used for making church bells than clock bells, and that a little zinc is added for the bells of repeating watches and other small bells.

IX.

SILVER COIN OF BRITAIN.

Put into a crucible, an ounce and seven drams of pure Silver, with one dram of Copper: they will combine by fusion.

Observation. This alloy is the same as that used for silver coin at the mint. It is harder and more durable than pure silver, and its lustre is not in the least impaired.

X.

GOLD COIN OF GREAT BRITAIN.

Put into a clean crucible one dram of pure Copper, and when it is in a fused state, throw in an ounce and 3 drams of pure Gold. These metals will combine, forming an Alloy of Gold with Copper, 22 carats fine.

Observations. The goodness of this alloy depends upon the relative quantities of the metals employed; it is said to be 22 carats fine, because 22 parts of gold have been used with 2 of copper: or as here directed, 11 drams of gold and one of copper, these being in the same proportion as 22 to 2. This alloy is rendered harder than pure gold, therefore not so liable to be worn away by friction in carrying it in the pocket. Pure gold loses very little of its colour by admixture with copper in these proportions. Jeweller's gold always contains *one half* of copper.

XI.

ALLOY OF LEAD AND TIN,

Harder than either Lead or Tin.

Melt 6 drams of Tin with 2 drams of Lead in a crucible. This Alloy will have acquired greater hardness and gravity than either of the components.

Observation. It certainly appears remarkable that tin should be rendered harder by a soft metal like lead.

XII.

ALLOY OF COPPER AND TIN

Of greater specific Gravity than the uncombined Metals.

Procure a proper mould, and form in it two balls of pure Copper, and two balls of pure Tin. Now put the Copper balls into a crucible, and when in a state of fusion put in the Tin balls. When both have been melted and properly combined, recast the Alloy, by pouring it into the mould. Instead of four balls, the operator will be able to form only three.

Observation. Here the quantity of metal is exactly the same as at first, but the alloy is capable of being more compact than the metals in a separate state.

XIII.

ALLOY OF COPPER AND ZINC,

Less in bulk than the component Metals.

Melt together 1 ounce of Copper and 6 drams of Zinc, having first denoted the bulk of each, by the quantity of water it displaces from a vessel,) and cast the compound in a mould. The Alloy, although still weighing 14 drams, will be found to be considerably diminished in bulk, compared with that of the two metals in a separate state.

Observations. This diminution of bulk is the consequence of an intimate union of the particles of both metals with each other. This alloy is a sort of brass. The above proportions are not the only ones in which these metals are used for the making of brass, but are varied according to the use to which the alloy is to be applied.

XIV.

DUCTILITY OF GOLD DESTROYED BY ANTIMONY.

To any quantity of Gold, from 2 drams to 4 ounces, add a single grain of Antimony, whilst the Gold is in a state of fusion. When cold it will be impossible to draw it out into wire; its ductility being completely destroyed by combination with the Antimony.

Observation. The power of antimony over gold is so great, that if two crucibles are put into a furnace, one containing antimony, and the other gold, the fumes which imperceptibly arise from the antimony in a state of fusion, will completely destroy the ductility of the gold.

XV.

DUCTILITY OF GOLD DESTROYED BY BISMUTH.

If the smallest speck or portion of Bismuth be thrown into a crucible containing Gold in a state of fusion, the Gold, when cold, cannot be drawn out into the state of wire, or beaten into a leaf.

Observation. A similar influence to that related in the foregoing experiment, (where the gold is rendered brittle by being kept in fusion near antimony), is exercised over gold, by bismuth under similar conditions.

XVI.

Queen's Metal.

Melt together 4½ ounces of Tin, half an ounce of Bismuth, half an ounce of Antimony, and half an ounce of Lead. A very excellent Alloy will be formed by using these proportions; it is called Queen's Metal, and is used for making teapots and other vessels which are required to imitate Silver. They retain their brilliancy to the last.

Observation. A very fine silver-looking metal is said to be composed of 100 pounds of tin, 8 of regulus of antimony, 1 of bismuth, and 4 of copper.

XVII.

Tombac.

Put into a crucible 5½ ounces of Copper; when fused, add ½ an ounce of Zinc; these metals will combine, forming an Alloy called Tombac, of a reddish colour, but possessing more lustre than Copper, and also greater durability:—that is, it is not so easily acted on by the atmosphere.

Observation. When copper is combined with arsenic, by melting them together in a close crucible, and covering the surface with muriate of soda, to prevent oxidation; a white brittle alloy is formed, which has been named *white tombac.*

XVIII.

Pewter.

Melt in a crucible 3½ pounds of Tin, and when fused, throw in 8 ounces of Lead, 3 of Copper, and 1 of Zinc. This combination of metals will form an Alloy of great durability and tenacity; also of considerable lustre. It is known by the name of Pewter.

Observation. The best sort of pewter is said to consist of 100 parts of tin, and of 17 of regulus of antimony.

XIX.

Composition of Ancient Statues.

According to Pliny, the metal used by the Romans for their statues, and for the plates on which they engraved inscriptions, was composed in the following manner. They first melted a quantity of Copper; into the melted Copper they put a third of its weight of old Copper, which had been long in use; to every hundred pounds weight of this mixture they added twelve pounds and a half of a mixture composed of equal parts of Lead and Tin.

XX.

Alloy for Flute-key Valves.

Fuse in a crucible 4 ounces of Lead and 2 ounces of Antimony, and cast it into a bar. This Alloy is of considerable hardness and lustre, and is used by Flute Manufacturers, (when turned into small buttons in a lathe,) for making valves to stop the key-holes of flutes.

XXI.

Alloy for Soldering.

Put into a crucible 2 ounces of Lead, and when it is melted, throw in an ounce of Tin. This Alloy is that generally known by the name of Solder. When heated by a hot iron, and applied to Tinned Iron with powdered rosin, it acts as a cement or solder; it is also used to join leaden pipes, &c.

XXII.

Useful Alloy of Gold with Platinum.

Put into a clean crucible 7 drams and a half of pure Gold, and when perfectly melted, throw in half a dram of Platinum. The two metals will combine intimately, forming an Alloy rather whiter than pure Gold, but remarkably *ductile* and *elastic*; it is also less perishable than pure Gold or jewellers' Gold; but more readily fusible than that metal.

Observations. These excellent qualities must render this alloy an object of great interest to workers in metals. For *Springs*, where steel cannot be used, it will prove exceedingly advantageous.

It is a curious circumstance, that the alloy of gold and platinum is soluble in nitric acid, which does not act on either of the metals, in a separate state. It is remarkable, too, that the alloy has very nearly the colour of platinum, even when composed of eleven parts of gold to one of the former metal.

ALLOYS OF STEEL WITH OTHER METALS.

Messrs. Stodart and Faraday have succeeded in forming some very useful Alloys by combining other metals with Steel; of which the Six following, with their Observations on them, are the most worthy of consideration.

XXIII.

ALLOY OF STEEL WITH PLATINUM.

The Alloys of Steel with Platinum, when both are in a state of fusion, are very perfect, in every proportion that has been tried. Equal parts by weight form a beautiful Alloy, which takes a fine polish, and does not tarnish; the colour is the finest imaginable for a mirror. The specific gravity of this beautiful compound is 9.862.

90 of Platinum with 20 of Steel, gave also a perfect Alloy, which has no disposition to tarnish; the specific gravity is 15.88; both these buttons are malleable, but have not yet been applied to any specific purpose.

10 of Platinum to 80 of Steel, form an excellent Alloy. This was ground and very highly polished to be tried as a mirror; a fine *damask*,* however, renders it quite unfit for that purpose.

Observations. Notwithstanding the well known character which platinum has for infusibility, it is remarkable that this metal, when in contact with steel, fuses at a temperature at which the latter metal is not affected. The proportions of platinum that appear to improve steel for edge instruments, are from 1 to 3 *per cent.* Experience does not yet enable us to state the exact proportion that forms the best possible alloy of these metals; 1.5 *per cent* will probably be very nearly the best. At the time of combining, 10 of platinum with 80 steel, with a view to a mirror; the same proportions were tried with nickel and steel; this too had the damask, and consequently was unfit for its intention. It is curious to observe the difference between these two alloys, as to susceptibility for oxygen. The platinum and steel, after lying many months, had not a spot on its surface, while that with nickel was covered with rust; they were in every respect left under similar circumstances.

XXIV.

ALLOY OF STEEL WITH RHODIUM.

The proportions we have used are from 1 to 2 *per cent.* The valuable properties of Rhodium Alloys are hardness, with sufficient tenacity to prevent cracking either in forging or in hardening. This superior hardness is so remarkable, that in tempering a few cutting instruments made from this Alloy, they required to be heated full 30° F. higher than the best Wootz; Wootz itself requiring to be heated full 40° above the best English cast Steel.

Observation. The alloys of steel with Rhodium are likely to prove highly valuable. The scarcity of the latter metal must, however, operate against their coming into use to any great extent.

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* A *waving* similar to that given to table-cloths, maroons, and other stuffs.

XXV.

CURIOUS ALLOYS OF SILVER WITH STEEL.

If Steel and Silver be kept in fusion together for a length of time, an Alloy is obtained, which appears to be very perfect while the metals are in the fluid state, but on solidifying and cooling, globules of pure Silver are expressed from the mass, and appear on the surface of the button. If an Alloy of this kind be forged into a bar, and then dissected by the action of dilute Sulphuric acid, the Silver appears, not in combination with the Steel, but in threads throughout the mass; so that the whole has the appearance of a bundle of fibres of Silver and Steel, as if they had been united by welding. The appearance of these Silver fibres is very beautiful; they are sometimes ¼th of an inch in length, aud suggested the idea of giving mechanical toughness to Steel, where a very perfect edge may not be required.

Observations. When silver and steel have been very long in a state of perfect fusion, the sides of the crucible, and frequently the top also, are covered with a fine and beautiful dew of minute globules of silver; this effect can be produced at pleasure. At first we were not successful in detecting silver by chemical tests in these buttons; and finding the steel uniformly improved, were disposed to attribute its excellence to an effect of the silver, or to a quantity too small to be tested. By subsequent experiments we were, however, able to detect the silver, even to less than 1 part in 500.

In making the silver alloys, the proportion first tried was 1 silver to 160 steel; the resulting buttons were uniformly steel and silver in fibres: the silver being likewise given out in globules during solidifying, and adhering to the surface of the fused button; some of these when forged gave out more globules of silver. In this state of mechanical mixture, the little bars, when exposed to a moist atmosphere, evidently produced voltaic action, and to this we are disposed to attribute the rapid destruction of the metal by oxidation, no such destructive action taking place when the two metals are chemically combined. These results indicated the necessity of diminishing the quantity of silver; and 1 silver to 200 steel was tried. Here, again, were fibres and globules in abundance. With 1 to 300, the fibres diminished, but still were present: they were detected even when the proportion of 1 to 400 was used.

XXVI.

USEFUL ALLOY OF SILVER WITH STEEL.

When 1 part of Silver and 500 parts of Steel were properly fused, a very fine button was produced. No Silver appeared on its surface; when forged, and dissected by an Acid, no fibres were seen, although examined by a highly magnifying power. The specimen forged remarkably well, although very hard; it had in every respect the most favourable appearance. By a delicate test, every part of the bar shewed Silver. This Alloy is decidedly superior to the very best Steel, and this excellence is unquestionably owing to combination with a minute portion of Silver. It has been repeatedly made, and always with the same success. Various cutting tools have been made from it of the best quality.

Observation. This alloy is perhaps only inferior to that of steel with rhodium, and it may be procured at a small expense; the value of the silver, where the proportion is so small, is not worthy of consideration; it will probably be applied to many important purposes in the arts.

XXVII.

WOOTZ.

Pure Steel, in small pieces, was heated intensely for a long time, and formed a highly crystalline Carburet. This being broken, and rubbed to powder in a mortar, was mixed with pure Alumine, and the whole intensely heated in a close crucible for a considerable time. The result was a brittle Alloy of a white colour, and close granular texture. When 700 grains of good Steel, and 40 of the Alumine Alloy, were fused together, they yielded a good malleable button, which being forged into a bar and polished, gave, by the application of diluted Sulphuric acid, the beautiful damask which is peculiar to Wootz; and which Wootz retains even after repeated fusions. A second specimen obtained from 500 grains of the same Steel, and 67 of the Alumine Alloy, possessed all the appreciable characters of the best Bombay Wootz.

XXVIII.

IMITATION OF METEORIC IRON.

In order to imitate the Siberian Meteoric Iron, Messrs. Stodart and Faraday fused some horse shoe nails with 10 per cent. of Nickel. The metals were found perfectly combined, and when polished, the Alloy had a yellow tinge. It was less rusted in a moist atmosphere than pure Iron, but what was singular, the same quantity of Nickel, when Alloyed with *Steel*, accelerated its rusting instead of preventing it.

XXIX.

PRINTER'S TYPES.

Put into a crucible 5 ounces of Lead, and when it is in a state of fusion, throw in an ounce of Antimony; these metals in such proportions form the Alloy of which common printing types are made. The Antimony gives a hardness to the Lead, without which, the type would speedily be rendered useless in a printing press.

XXX.

Alloy for Small Types, and Stereotype Plates.

Melt 4½ ounces of Lead, and throw into the crucible an ounce of Antimony and half an ounce of Bismuth: these metals will combine, forming an Alloy of a peculiar quality. This quality is expansion as it cools; it is therefore well suited for the formation of small printing types, (particularly when many are cast together to form Stereotype plates), as the whole of the mould is accurately filled with the Alloy; consequently there can be no blemish in the letters. But if a metal or Alloy liable to *contract* in cooling were to be used; the effect of course would be very different.

Observation. The proprietors of different founderies adopt different compositions for stereotype plates. Some form an alloy of 8 parts of lead, 2 parts of antimony, and ½ part of tin.

XXXI.

Very Fusible Alloys.

Put into a crucible 4 ounces of Bismuth, and when in a state of fusion, throw in 2½ ounces of Lead, and an ounce and a half of Tin; these metals will combine, forming an Alloy fusible at the temperature of boiling water; the discovery of which is ascribed to Sir Isaac Newton. Mould this Alloy in bars, and take them to a Silversmith's to be made into half a dozen tea-spoons. If one of these be given to a stranger to stir his tea, as soon as it is poured from the teapot; he will be not a little surprised to find the spoon melt in the teacup.

Observation. The fusibility of this alloy is certainly surprising, for the fusing temperature of each of its components singly, is higher than twice that of boiling water. Bismuth fuses at 476°, lead at 612°, and tin at 442°; whilst water boils at 212°.

XXXII.

Melt together an ounce of Zinc, an ounce of Bismuth, and an ounce of Lead; this Alloy is remarkably fusible, (although each of the metals separately requires considerable heat to melt it), and may be melted even by moderately hot water:—it is said that this Alloy will remain in a fused state on a sheet of paper, over the flame of a lamp or candle.

Observation. This composition, with the addition of a small proportion of mercury, is used for injecting the vessels of various anatomical preparations; also for taking correct casts of various cavities of the body, as those of the ear. The animal structure may be corroded and separated by means of a solution of potass in water; and the metallic cast will be preserved in an isolated state.

AMALGAMS.

AMALGAMATION is the combination of Mercury with any other metal. The compound has always been called an Amalgam, though properly speaking it is an Alloy. The general way of combining Mercury with metals is by heat. Amalgams of some metals may be made by merely triturating them with Mercury in a mortar.

XXXIII.

Amalgam of Gold or Silver.

Place a Gold leaf in the palm of the hand, and pour upon it a globule of Mercury. The latter will be seen to absorb, or combine with the Gold, in the same manner as sugar or table salt mixes with water.

Observations. Persons who have taken mercurial preparations internally, seldom fail to observe the readiness with which the mercury transudes through the pores of their skin, attaching itself to the gold of their watches, rings, sleeve-buttons, or ear-rings, and rendering them of a white colour. A piece of gold, of the thickness even of a guinea, being rubbed with quicksilver, is soon penetrated by it, and made so fragile, that it may be broken between the fingers with ease.

It is this property which quicksilver has of uniting itself with gold, and silver, that has rendered it of such great use to the Spaniards in America. They reduce the earths or stones, containing gold or silver in their metallic states, into a very fine powder; they mix this powder with quicksilver; and the quicksilver, having the quality of uniting itself with every particle of those precious metals, but being incapable of uniting with any particle of earth, extracts the metals from the largest portions of earth. The quicksilver, which has absorbed either gold, or silver, or a mixture of both, is separated from the substance it has absorbed by evaporation; the quicksilver flies off in vapour, and the precious metal remains in the vessel.

XXXIV.

Put two drams of Mercury into a crucible, and heat it until a vapour be seen to arise from it; now throw into the crucible 1 dram of Gold or Silver, and stir them with an Iron rod. When the Gold or Silver is known to be fused, the Amalgam is formed, and should be poured into a bason of cold water; when cool, pour off the water, and collect the Amalgam, which will be a yellowish silvery mass of about the consistency of soft butter. This, after having been bruised in a mortar, or shaken in a strong phial, with repeated portions of salt and water, (till the water ceases to be fouled by it,) is fit for use, and may be kept for any length of time without injury, in a corked phial.

Observations. It is of essential importance that the materials of this amalgam, and especially the mercury, should be perfectly pure, as the least portion of lead or bismuth would very materially injure the beauty of the gilding, (when the amalgam is used for this purpose,) by deteriorating the colour of the gold, and filling it with black specks. On this account, no mercury should be employed but what has been distilled from the red oxide of mercury, (red precipitate) either alone, or mixed with a little charcoal powder. When any substance is to be silvered or gilt, it must be first made very clean; (copper, for example) then rubbed over with the amalgam, and then exposed to a heat of 656°; when the mercury will fly off, leaving a coat of silver or gold on the copper. There are furnaces constructed for the volatilization of mercury from gilded vessels, by which the vapour of the mercury is prevented from affecting the hands or face of the operator: before this invention, gilding was a very unwholesome occupation.

XXXV.

AMALGAM OF SODIUM.

Place a globule of Sodium, weighing 15 grains, in a dry watch-glass, and bring into contact with it 10 grains of Mercury. They will instantly combine, forming a solid Alloy of beautiful lustre. During this combination, considerable heat will be given out.

XXXVI.

AMALGAM OF POTASSIUM.

Place a globule of Mercury of the size of a pea, on a piece of writing paper, and bring near to it a globule of Potassium of the size of swan shot; touch the paper so that the two metals may come in contact. The instant this takes place, heat will be given out, and they will incorporate, forming a complete Amalgam.

Observation. This amalgam, in a few seconds, will become solid, although only a small quantity of a solid metal has been used, with double its size of a fluid one. It is by this consolidation and condensation of their particles that the heat is given out: consequently the specific gravity of the new compound is greater than that of the separate bodies.

XXXVII.

PHENOMENA ON THE SEPARATION OF POTASSIUM FROM ITS AMALGAM.

Put the above mentioned solid amalgam into a tea-cup, containing warm or cold water:—The Potassium will here shew its greater affinity for Oxygen than for Mercury, by quickly leaving the latter (which of course sinks to the bottom), and combining with the former, which it takes from the water. The Hydrogen will be set free, and the whole action will be accompanied by considerable noise. Turmeric paper immersed in the tea-cup will show that a solution of Potass has been formed. A similar effect will take place, but unaccompanied by noise, when this Amalgam is exposed to the action of the air.

XXXVIII.

Amalgam for the Cushions of Electrical Machinery.

Melt together in a crucible 2 drams of Zinc, and 1 of Tin; when fused pour them into a cold crucible, containing 5 drams of Mercury. The Mercury will combine with those metals, and form an Alloy, (or Amalgam, as it is called,) fit to be rubbed on the cushions which press the plate or cylinder of an Electrical machine. Before the Amalgam is applied, it is proper to rub the cushion with a mixture of tallow and bees-wax.

XXXIX.

Alloy for Varnishing Figures.

Fuse ½ an ounce of Tin, with the same quantity of Bismuth, in a crucible; when melted, add ½ an ounce of Mercury. When perfectly combined, take the mixture from the fire and cool it. This substance, mixed with the white of an egg, forms a very beautiful varnish, for plaster figures, &c.

XL.

Alloy for Silvering Glass Globes, &c.

For this purpose, 1 part of Mercury and 4 of Tin have been used; but if two parts of Mercury, one of Tin, one of Lead, and one of Bismuth, are melted together, the compound which they form, will answer the purpose better: either of them must be made in an iron ladle, over a clear fire, and must be frequently stirred. The glass to be silvered must be very dry and clean. The Alloy is poured in at the top, and shaken until the whole internal surface is covered.

XLI.

Alloys, which fuse when rubbed together.

Melt 2 drams of Bismuth and 2 drams of Lead in separate crucibles; pour them into separate vessels, containing a dram of Mercury in each; when cold, these Alloys will be in a solid state, but if they are rubbed against each other, they will instantly enter into fusion.

COMBINATION OF METALS WITH OTHER SUBSTANCES.

Although the subjects of the six following experiments do not strictly come under the head of Alloys; still, as after preparation, the compounds possess a metallic lustre, they are inserted in this place.

XLII.

TRANSFORMATION OF IRON INTO STEEL.

Fuse by a considerable heat in a crucible, about 4 ounces of Cast iron (which is a Carburet of iron.) Whilst in a state of fusion, immerse in it a polished Iron wire about $\frac{1}{8}$ or $\frac{1}{10}$ of an inch in diameter, and keep it there for a considerable time, but not so long as to fuse it. When cold, the wire will be so hard as to resist the action of a common file, being converted into Steel.

Observations. Here the pure iron robs the carburet of a portion of its carbon, and is itself converted into a carburet. The conversion of iron into steel in this way may be proved by dipping the end of the wire in nitric acid; when it will turn black: this will not be the case with pure iron.

Another process for making steel, is by cementation, or heating iron with charcoal in a crucible. This process can be stopped before the surface has been so far penetrated as to convert the whole substance of the iron into steel. The operation is called case-hardening.

No fact can be of greater importance to the artist, than to know how to give to steel an exact degree of temper, varying, however, exactly according to the various purposes to which that steel is intended to be applied. The wootz of the Indians has very remarkable qualities, and may be considered as steel of a very superior kind, or at least of having properties equal to steel of the first manufacture. When the surface of any piece of steel, after having been cleaned perfectly by polishing or grinding, is heated again to a certain temperature, it first acquires a straw colour, which will gradually, on receiving a higher heat, change to a full gold colour with ruddy purple streaks, then afterwards become of a full purple violet, and lastly ultra-marine blue. These colours, respectively, direct the artist to stop within that range of temperature at which they occur, to arrest the temper, which is done by plunging the metal into cold water, or grease, which by particular artists is occasionally employed. The first degree of yellow, in the act of tempering, fits the steel for the hardness requisite for the edges of chisels and punches which are to be employed upon iron itself. The full gold colour or incipient purple hue fits the steel for chisels which are to be employed upon the softer metals; if we go on to a somewhat deeper tint of purple, we obtain that state which is best adapted for edge tools; whilst the full violet or blue, is the condition always sought in the manufacture of watch springs.

When clouds of a dingy yellow, (which will occur, unless care be used,) intersect the blue, a degree of softness foreign to the views of the artist is produced.

Steel is much more readily broken by bending than iron: when a bar of it is broken, the fracture is quite different from that of iron. A bar of tough iron exhibits a fibrous appearance on fracture, the surface being very rough and rigid at the ends of the respective fibres: when steel is broken it shews that it is composed of strong grains of a plated structure, and presents a whitish grey surface much plainer than that of broken iron.

The most useful qualities, by which steel excels iron, are the strong cohesion of its parts, and the extraordinary hardness it acquires on being suddenly cooled after having been made red hot. It can thus be hardened to so high a degree, as not only to cut iron with ease, but even steel itself, in its softer state. Dr. Black asserts, that a steel wire of one-tenth of an inch in diameter, will just break when loaded with 900 lbs. weight, if properly tempered; but it will lift upwards of 700 lbs. weight in its tough state.

This excessive hardness is attended with perfect rigidity and inflexibility; and, in consequence steel is to a certain degree brittle. Files, for instance, when hardened to this degree, can be broken by simply dropping them on the ground.

XLIII.

MANUFACTURE OF STEEL IN PERSIA.

At the Laboratory of the Royal Institution, London, Oostad Muhammed Ali, a noble Persian, thus described the Persian mode of manufacturing Steel.

Iron is brought from the mountains; a square place is built up, about four feet in the side, and five or six feet high, the walls being eight or nine inches thick; stones of a slaty kind are put across this on the inside,about eighteen inches from the bottom, so as to form a grate; below this is a chamber for the reception of the melted Steel, and above it is placed the Iron, in bars, and Charcoal intermingled together. There are three apertures just above the grate into the furnace, into which air is propelled from bellows, worked by men sitting; a fire is lighted, and the heat raised, fresh Charcoal is thrown on, as that in the furnace burns away; and as the Iron becomes carbonized, it melts and falls through the grate, as fluid cast Steel, into the chamber beneath, from whence it is taken and cast into ingots.

From 3 to 4 cwt. is placed in such a furnace, and there is a loss of about one third from oxidation and adhesion to the sides. The operation requires from 3 to 4 days, with constant blowing. Muhammed Ali described the Charcoal as being exceedingly heavy and hard, and very unlike our Charcoal; but he did not know of what wood it was made.

XLIV.

To make Cast Steel.

Put 20 parts of pure Iron in small pieces into a crucible, with 6 parts of powdered chalk, and 6 parts of powdered Hessian crucible ware. Dispose the whole so, that after fusion, the Iron may be completely covered, to prevent the least contact with the air. Now give the crucible a gradual heat, and then expose it to a white heat. Generally, an hour will be sufficient to convert 2 pounds of Iron into exceedingly hard Steel, capable of being forged; an advantage not possessed by Steel in the usual manner.

Observations. Here the iron is formed into a carburet by combination with the carbon of the chalk and crucible powder.

In the present age of invention and improvement in the arts, none seems to promise greater benefits to society, than Messrs. Perkins, Fairman, and Heath's *Siderographia*; or mode of engraving upon steel, and then transferring the same to steel or other metals. This invention deservedly demands while it receives the admiration of every lover of the Fine Arts; and at the same time it presents the means of perpetuating whatever is beautiful in the art of engraving, and will probably produce a general refinement in the public taste, by furnishing engravings of the most beautiful kinds, at the same cost as those of inferior execution.—The advantages to be derived from the use of this invention are various; but that to which it has been applied almost exclusively, and with perfect success, has been, to SECURE PAPER CURRENCY FROM FORGERY; an object not before attained by any other plan, but of the first importance as it respects national morality, which cannot be maintained except by the absence of temptation to crime.

Having been permitted to examine the Siderographic process, we proceed to lay a concise account of it before our readers. Steel blocks or plates of sufficient size to receive the intended engraving are softened or decarbonated upon their surfaces, and thereby rendered a better material for receiving all kinds of work than even copper itself. After the intended work has been executed upon the block, it is then hardened with great care by a new process which prevents injury to the most delicate work.—A cylinder of steel, previously softened, is then placed in the transferring press, and repeatedly passed over the engraved block, by which the engraving is transferred *in relief* to the periphery of the cylinder, the press having a vibrating motion equalling that of the cylinder upon its axis, by which, new surfaces are presented equalling the extent of engraving. This cylinder is then hardened, and is ready for indenting either copper or steel plates, which is done by placing it in the same press before described, and repeatedly passing it over the copper or steel plates, thereby producing another engraving *identically* like that upon the *original* block; and this may be repeated upon any required number of plates, as the original engraving will remain to produce other cylinders if ever required, and when transferred to steel plates and hardened, these will also serve as additional matrices for the production of new cylinders. This invention promises to be of great advantage to some of our manufactures, particularly that of pottery, which may now be embellished with beautiful engravings, so as to place the successful competition of other nations at a more distant period. It may also be applied with great advantage to CALICO printing, by producing entire new patterns upon the cylinders from which they are printed, an object of great importance to our manufacturing interests. These are among its obvious applications; but as a means of rendering Forgery IMPRACTICABLE, it claims the attention of statesmen and the gratitude of philanthropists, who shudder at the hundreds of victims which are now immolated to the laws, by the facility with which they may be violated.

XLV

PREPARATION OF CRYSTALLIZED SULPHURET OF IRON

Similar to that found in Slates, &c.

Weigh 1 ounce 4 drams and 32 grains of pure Iron filings; also 1 ounce 6 drams and 40 grains of Sulphur. Put the Sulphur into a clean crucible, and when fused, put the Iron filings in. These substances will unite into a body, of the lustre of pure Gold. If the crucible be left to cool a little; and if when a crust is formed at the top, the bottom be broken off, a cubical crystalline structure will be displayed.

Observations. In Wales, when the rocks are blasted for the purposes of making roads, square cubes are found of a bright metallic appearance, very much resembling dice, the sides and angles of which are as true as if formed and polished by the hand of an experienced mechanic. They consist of sulphur and iron: large quantities of them lie about the mouths of the Paris mines in Anglesea. Their size varies from 1-8th to 3-4ths of an inch in diameter, and they are generally imbedded so firmly in the matrix of the stone, that it is difficult to extract them perfect.

XLVI.

PREPARATION OF AURUM MUSIVUM.

If 2 ounces of Sulphur and 2 ounces of Oxide of Tin are put into a retort, and submitted to a considerable heat until the Oxygen is driven off from the Tin, with part of the Sulphur, in the form of Sulphurous acid; a beautiful yellow scaly substance, having a metallic lustre like Gold, will remain. This has been termed Aurum Musivum or Mosaic Gold, but it is really a Sulphuret of Tin.

Observation. It is probable that this was one of the substances which the alchymists of the middle ages were enabled to impose on their credulous contemporaries as *transmuted gold.*

XLVII.

PHOSPHURET OF NICKEL.

Nickel combines with Phosphorus. This is done by decomposing Phosphoric acid:—that is, by mixing Phosphoric glass, Charcoal, and Nickel, and fusing them together; or, it may be prepared by adding bits of Phosphorus to the metal while it is red hot, in a crucible. It acquires an addition of one-fifth part of its weight, but it parts with a small portion of Phosphorus as it cools. The Phosphuret of Nickel is of a more brilliant and pure white than the metal itself. Its texture resembles a collection of small needles heaped together.

Observations. Nickel combines readily with sulphur, and forms with it a sulphuret, which is somewhat different in its properties from the native sulphuret. It is hard, of a yellowish colour, and in small brilliant facets. When it is strongly heated in the open air, it gives out luminous sparks.

Nickel enters into combination with several of the metals, and forms with them alloys, the properties of which are but little known. With cobalt and arsenic it forms native alloys. The alloy with the latter is of a reddish colour, has no magnetic property, is considerably harder, and its specific gravity is less than the mean specific gravity of the two metals.

XLVIII.

PHOSPHURET OF COPPER.

The following is a mode of giving to Copper the grain and hardness of Steel. The Copper is to be fused with two parts of Phosphoric glass and 1-12th of Charcoal powder. The shavings of the metal are to be placed in strata, with the glass and Charcoal powder, and the crucible exposed to a fire sufficiently strong to fuse the glass. There is thus formed Phosphorus, the greater part of which burns, while the rest combines with the Copper. When the crucible has cooled and is broken, the Phosphorated Copper is found in the form of a grey brilliant button under the glass, which has passed to a state of red enamel. By this operation it is increased in weight one-twelfth.

Observations. The copper thus combined with phosphorus acquires the hardness of steel, of which it has the grain and colour, and like it, is susceptible of the finest polish: it can be easily turned, and does not become altered in the air. The copper emits no smell when rubbed.

The dark red enamel which is formed in this experiment, may be employed with advantage for porcelain and other enamels, as this red does not alter in the fire.

WELDING.

Welding is the art of joining by means of heat and percussion, two or more pieces of the same metal; so as when *finished or polished to appear one single piece, without the least mark or fissure, and rendering rivets or solder unnecessary. The Metals which are capable of being welded are very few; but of these, Platinum and Iron are thereby rendered of the greatest utility for the manufacture of vessels, &c. which require toughness; such as Steam-engine boilers. The extreme infusibility of Platinum renders its welding property of the greatest advantage, as it would otherwise be almost absolutely impossible to form it into vessels of capacity.*

XLIX.

WELDING OF IRON.

Place two bars of Iron in a blacksmith's forge, and give them a white heat; observe now when one of them at its hot part has a glossy surface; in this case, take out both pieces quickly; let an assistant place them on an anvil one above the other, and strike hard and repeatedly with a large hammer: the two bars will now be incorporated, or *welded* together, and their junction cannot be discovered, if the operation has been well conducted.

Observation. The art of welding iron is familiarly known to every parish blacksmith;—indeed it constitutes the principal part of his art: for without this property, iron could not be formed into chains, or other articles, whose cohesion at the joints are intended to resist great mechanical force. In China, near Kingtung, there is a bridge, which extends between two high mountains, formed entirely of *welded iron*. It is composed of chains; viz. 21 in number, which stretch across the valley, and are held in their proper positions by others which cross them. This is truly a proud monument of the arts in a country which some term *barbarous.*

In England, the ingenuity and perseverance of Mr. Telford, will shortly accomplish a work of similar magnitude over the *Menai Strait;* viz. to connect Wales with the Isle of Anglesea.

L.

WELDING PROPERTY OF PLATINUM.

Place two small bars of Platinum on a forge, and give them an intense heat. When they are quite *white,* and present a glossy surface, place one above the other on an anvil, and strike them hard with a hammer: the two pieces will unite, as if they had been part of the same bar. This, and the malleable property of Platinum render it very useful for the formation of chemical vessels or utensils; as Platinum is so *infusible* as not to allow of being cast into a mould.

LI.

WELDING PROPERTY OF SODIUM.

If four or five pieces of Sodium are brought together on a table, and pressed upon heavily by a knife or piece of wood, the whole will be welded into one piece of metal; nor can it afterwards be discovered where they were joined.

LII.

WELDING OF STEEL AND CAST IRON.

The welding of cast Steel and cast Iron has hitherto been considered a very difficult process; and the chief cause of failure has been in giving them too much heat, thinking that they required as much as wrought Iron. The best fluxes for this purpose are glass of borax, and ground green bottle glass. In order to weld Steel, a Charcoal fire should be used. The pieces, after being formed of a proper shape for uniting, should have the surfaces intended to be joined, filed bright; be coated with borax; and be bound together firmly by bands or hoops, previously to their being put into the fire. As soon as they are heated sufficiently to fuse the glass of borax, or bottle glass, they should be coated therewith on their outsides; either by dipping them into these substances powdered, or by sprinkling them over with them. More heat, if absolutely necessary to effect their union, must be employed. By these means the properties of the Steel will be as little injured as possible.

LIII.

WELDING OF PLATINUM WITH STEEL.

Messrs. Stodart and Faraday packed together wires of Platinum and Steel, of about equal diameter, and perfectly united them by welding. This was done with great ease. On being forged, the surface polished, and an acid having been applied to the compound, a very novel and beautiful surface appeared; the two metals forming dark and white clouds. If this can be effected with very fine wires, a damasked surface will be obtained, of exquisite beauty.

CHAPTER II.

ART OF COATING METALS, &c. WITH METALS

THIS art is what is generally understood by the terms silvering, gilding, tinning, &c. &c. It will be seen by the following Experiments, that the modes of conducting these several operations are various; but the most common method is by precipitation. Metallic precipitates are obtained by the power which other substances exert, in uniting themselves to their solvents. The metals are thus deoxidated, and fall down in the pure or *reguline* state.

LIV.

PRECIPITATION OF MERCURY ON COPPER.

Drop a solution of the Nitrate of Mercury on a plate of clean Copper, so that the whole surface may be equally covered. Wipe the liquid off gently, and rub the Copper dry with a piece of soft leather. The plate will now be covered with a coat of metallic Mercury.

LV.

PRECIPITATION OF COPPER ON ZINC.

Into a wine glass nearly filled with distilled water, put 10 grains of powdered Sulphate of Copper, and 2 drops of Nitric acid; stir the whole with a glass rod, until the salt be dissolved: then immerse a rod of Zinc; the Copper will be immediately precipitated upon the rod in the metallic form.

LVI.

PRECIPITATION OF GOLD UPON IRON.

If a bright or well polished Iron rod be immersed in a solution of Nitro-muriate of Gold, the Gold will be precipitated on it in the metallic state.

LVII.

PRECIPITATION OF LEAD ON ZINC;

Or, to prepare the Leaden Tree.

Put half an ounce of the Super-acetate of Lead in powder, into a clear glass globe, or wine decanter, filled to the bottom of the neck with distilled water; add 10 drops of Nitric acid, and shake the mixture well. Prepare a rod of Zinc with a hammer and file, so that it may be a quarter of an inch thick, and an inch long; at the same time, form notches in each side for a thread, by which it is to be suspended, and tie the thread so, that the knot shall be uppermost, when the metal hangs quite perpendicular. When it is tied, pass the two ends of the thread through a perforation in the cork, and let them be again tied over a small splinter of wood which may pass between them and the cork. In tying the string, let the length between the cork and the Zinc be such, that the precipitant (the Zinc) may be at equal distances from the sides, bottom, and top, of the vessel, when immersed in it. When all things are thus prepared, place the vessel in a place where it may not be disturbed, and introduce the Zinc, at the same time fitting in the cork. The metal will very soon be covered by the Lead, which it precipitates from the solution, and this will continue to take place until the whole become attached to the Zinc, assuming the form of a tree or bush, whose leaves and branches are laminal, or in plates of a metallic lustre.

LVIII.

PRECIPITATION OF TIN UPON ZINC;

Or, the Tin Tree.

Into the same, or a similar vessel to that used in the last Experiment, pour distilled water as before, and put in 3 drams of Muriate of Tin, adding 10 drops of Nitric acid, and shake the vessel until the salt be completely dissolved. Replace the Zinc (which must be cleaned from the effects of the former experiment), as before, and set the whole aside to precipitate without disturbance. In a few hours, the effect will be similar to the last, only that the tree of Tin will have more lustre.

Observation. In these experiments, it is surprising to observe the laminæ shoot out as it were from nothing; but this phenomenon seems to proceed from a galvanic action of the metals and the water.

LIX.

PRECIPITATION OF SILVER BY MERCURY;

Or, the Silver Tree.

Pour into a glass globe or decanter 4 drams of Nitrate of Silver, dissolved in a pint or more of distilled water, and lay the vessel on the chimney piece, or in some place where it may not be disturbed. Now pour in 4 drams of Mercury. In a short time the Silver will be precipitated in the most beautiful arborescent form, resembling real vegetation. This has been generally termed the Arbor Dianæ or Tree of Diana.

Observations. Another way of producing the Arbor Dianæ, is by pouring into a diluted solution of nitrate of silver as above, 2 drams of nitrate of mercury, dissolved in 4 drams of water.

A third way of preparing the Silver tree, is by dissolving 6 drams of nitrate of silver, and 4 drams of nitrate of mercury, in a decanter of distilled water; and dropping into it, 6 drams of an amalgam of silver, composed of 3 drams of mercury, and one of silver. The latter plan is perhaps the most approved one.

LX.

PRECIPITATION OF BISMUTH ON COPPER.

If a Copper rod be immersed in a solution of 20 drops of the Nitrate of Bismuth, in a wine glass full of water; it will soon be covered by a brilliant precipitate of that metal.

LXI.

PRECIPITATION OF SILVER ON COPPER.

Dissolve 10 grains of the crystallized Nitrate of Silver in a wine glass full of water; and immerse a clean slip or rod of Copper; a beautiful metallic precipitate will immediately begin to take place upon it. The Silver will be seen, as it were, to dart into existence in the crystalline form.

LXII.

A very pleasing variation of the last experiment may be made as follows. Dissolve 15 grains of Nitrate of Silver in half a dram of water, and pour some of the mixture on a piece of clean window glass: bring the Copper rod just in contact with the solution, and let the whole remain undisturbed for about 3 or 4 hours; at the end of that time, a beautiful white metallic crystalline precipitate will have taken place on the glass, in that spot where the rod is most contiguous to the solution. If the rod, (or a copper wire) be bent, and employed for the same purpose, the precipitation will take place on all parts of the glass, where this metal comes in contact with the fluid.

Observations. A still more beautiful effect takes place when several drops of the solution of nitrate of silver are let fall on a plate of polished copper. Here, in a very short time, a brilliant precipitation of metallic silver will take place in an arborescent form. The causes of all these phenomena are the affinity which copper has for nitric acid; its abstraction of it from other bodies which have less affinity for it; and the consequent precipitation of the uncombined metal in a crystalline state.

LXIII.

ART OF SILVERING COPPER, &c.

Dissolve a grain of Nitrate of Silver in water, and immerse in it a piece of very clean Copper; the Silver will be precipitated on it. When no more Silver will fall down, wipe it off from the Copper with a feather or a piece of paper, and after having pressed out the water, weigh 15 grains of it, to be mixed with 2 drams of Super-tartrate of Potass, 2 drams of Muriate of Soda, and 30 grains of Sulphate of Alumine and Potass. When these substances are properly combined, let them be rubbed on any clean piece of Brass or Copper. A white shining coat of Silver will presently appear, which will bear repeated polishing with leather.

Observations. In making French plate; copper, or more commonly brass, is heated to a certain degree, and silver leaf is applied upon the heated metal, to which it adheres by burnishing. It is evident, that the durability of the plating must depend on the number of leaves which are applied on the same quantity of surface. For ornaments which are not much used, ten leaves may be sufficient; but an hundred will not last long, without betraying the metal they are designed to cover, if they be exposed to much handling, or be frequently washed.

After the same manner may gold leaf be applied, either on iron or copper.

LXIV.

PRECIPITATION OF SILVER

From the Muriate, on Copper, Brass, &c. Being the method of Silvering Clock, Barometer, and Thermometer Plates

Mix together equal parts of Muriate of Silver and moistened Supertartrate of Potass: with this rub the plate to be silvered, until the whole has received a complete coat sufficient to preserve it from corrosion. During the operation, it may be frequently heated, and immersed in distilled water, to wash away the superfluous saline matter.

LXV.

REDUCTION OF SILVER

From the Ammoniuret, on Copper.

Precipitate Oxide of Silver from the Nitrate, by Potass:

filter, wash, and dry it. Dissolve this Oxide in pure liquid Ammonia; the solution will be of a yellow colour. Immerse a slip of polished Copper in it, and let the moisture evaporate; when the Copper is quite dry, hold it over a charcoal fire. The Oxide will be decomposed, and the metal reduced on the Copper in the form of a complete coating. This may be made beautifully bright by polishing with leather.

LXVI.

PRECIPITATION OF COPPER ON SILVER AND IRON.

If a Silver spoon be immersed in a solution of Sulphate of Copper, both the metal and solution will remain unaltered; but if a polished Iron rod also be immersed in this liquid, so that the lower ends of each may come in contact, a precipitation of metallic Copper will take place on both the rod and spoon: that is, they will both be covered with a coat of Copper.

Observation. In this experiment, the metals and the solution form a galvanic series.

LXVII.

REDUCTION OF SILVER

From the Nitrate, upon Phosphorus, by the Sun's rays.

Prepare a very diluted solution of Nitrate of Silver in a wine glass: place it in a window, and immerse in it a piece of Phosphorus. In a day or two, the Phosphorus will be completely covered with a coat of Silver.

Observation. This reduction of a metal from its solution is effected by the action of the light; but *how* it is effected, chemists in the present state of the science, are not agreed.

LXVIII.

ART OF SILVERING IVORY.

Prepare a diluted solution of Nitrate of Silver, and immerse in it an Ivory paper knife. When the Ivory has become yellow, in that part where it is in contact with the fluid; take it out and immerse it in an ale glass, containing distilled water, placed in a window; in a short time, by exposure to the rays of the sun, it will become intensely black.

Take it out of the water, and having wiped it dry, rub it with a piece of leather. The Silver will now appear on the Ivory in a metallic state. The knife will retain its Silvery coat for a long time.

LXIX.

PRECIPITATION OF SILVER ON CHARCOAL;

With Deflagration.

If two or three small crystals of Nitrate of Silver, be thrown into a crucible, containing two or three pieces of red hot Charcoal, violent detonation and combustion will take place. If the Charcoal be now taken out, it will be found covered with Silver.

Observation. In this experiment, the salt is decomposed by the charcoal, which having taken the oxygen to itself, (to be converted into carbonic acid gas,) the silver is precipitated, in the metallic state. The pieces of charcoal should be preserved in a well stopped dry phial.

LXX.

REDUCTION OF SILVER FROM THE NITRATE

Upon Charcoal, by the action of the Sun's rays.

Immerse a thin slip of Charcoal in a glass, containing a solution of Nitrate of Silver; place the glass in a window, and leave it undisturbed; a film of metallic Silver will be deposited over the whole surface.

LXXI.

PRECIPITATION OF METALLIC COPPER

From the Sulphate, by Iron.

Dissolve some crystals of Sulphate, or any other salt of Copper in distilled water, and immerse the blade of a penknife: it will instantly be covered by a coat of metallic Copper. In this way, streams of water, which have flowed through Copper mines, (and which hold Sulphate of Copper in solution), are decomposed by throwing in waste Iron. In these cases, Sulphate of Iron is formed (and may be crystallised,) whilst the Copper is precipitated.

Observation. This copper, when afterwards melted, is considered to be the purest and most ductile used in the manufactures.

LXXII.

PRECIPITATION OF TELLURIUM BY IRON.

When an Iron rod is dipped in a solution of Muriate or any other salt of Tellurium, that metal will be precipitated on it, in the form of a black powder; which by friction will soon exhibit a metallic lustre.

Observation. Tellurium, from all its solutions, may be precipitated in the metallic state by zinc and muriate of tin. In the same way, iron or its solutions, will precipitate palladium of a brilliant silver like colour.

LXXIII.

To Platinise Brass, &c. &c.

Dip a clean polished Brass rod into an Ethereal solution of Platinum: it will, when withdrawn, be covered with a beautiful silver-white coating of Platinum, very durable, and difficult to be rubbed off. In this way, polished brass plates, also handles and knockers for doors, may be very economically covered by a coating, which is sure to preserve them from the action of the atmosphere, &c. and consequently, prevent much trouble in cleaning. When plates are to be covered, a clean rag may be dipped in the solution, and passed over them in a gentle manner.

LXXIV.

Precipitation of Bismuth by Tin.

Dissolve 10 grains of Nitrate of Bismuth in a wine glass of distilled water, and add 2 drops of Nitric acid. Stir the whole with a glass rod, and then immerse a rod, or other piece of Tin. The Bismuth will immediately begin to be precipitated on it, in very small shining plates.

LXXV.

Method of Tinning Brass Pins.

Fill a Tinned copper vessel, with alternate layers of Brass Pins, and plates or pieces of Tin. Now pour over the whole a saturated solution of Super-tartrate of Potass in hot water, so that the vessel may be quite full. Now place the vessel upon the fire, and let the liquid boil for 5 or 6 hours. When cold, the Pins will be completely coated by the Tin, which being dissolved by the salt, is precipitated on the Brass.

Observation. Tin tacks are whitened in a similar manner.

LXXVI.

Art of Tinning Iron.

Clean with coal ashes a slip of sheet Iron, so that it may possess a good lustre; and put it in a vessel containing a quart of water and one dram of Sulphuric acid: let it remain in this state for a day and a night. Take it out at the end of that time, and dry it well; then grease it with a piece of tallow, and put it in a hot oven or other place. Now melt an ounce of Tin in a crucible, and dip the clean slip whilst *hot* in it, taking care that the Tin shall cover all parts of it. When cut in pieces by a pair of scissars, the metals will be found to have completely combined, for the whole will possess a silvery lustre.

Observations. This, on a small scale, is the mode in which sheets of iron are tinned at the manufactories. When the iron plates have been either hammered or rolled to a proper thickness, they are steeped in an acid liquor, which is produced from the fermentation of barley meal, although any other weak acid will answer the purpose; this steeping, and a subsequent scouring, cleans the surface of the iron from every speck of rust or blackness, the least particle of which would hinder the tin from adhering. After the plates have been made quite bright, they are put into an iron pot filled with melted tin; the surface of the melted tin is kept covered by suet or pitch, or some fat substance, to prevent it from being oxidised; the tin presently unites itself to the iron, covering each side of every plate with a thin white coat: the plates are then taken out; and (after undergoing some further operations, which render them more neat and saleable,) are packed up in boxes. These are every where to be met with in commerce, under the name of tin-plates, though the principal part of their substance is iron.

LXXVII.

ART OF TINNING COPPER.

Clean a slip of Copper from all impurities, by using a piece of flannel and whiting, and afterwards removing any dust by polishing it with leather. Next rub it over with Muriate of Ammonia. Then heat the slip, and immediately afterwards rub it over with a piece of tallow or pitch. Now heat it again, and rub it over with a piece of Tin; this metal will immediately combine with the surface, giving it a silvery coat.

Observations. The mixture generally used for the tinning of copper vessels, consists of 3 pounds of lead, and 5 pounds of pewter; when a finer composition is required, ten parts of lead are mixed with sixteen of tin; or one part of lead with two of tin: but the proportions in which lead and tin are mixed together, even for the same kind of work, are not every where the same; different artists having different methods. Vessels tinned with pure tin, or with the best kind of pewter, (which contains no lead,) do not stain the fingers when rubbed by them: whilst those which are tinned with a composition into which lead enters as a constituent part, colour the fingers of a blackish tinge.

The common method of tinning consists in making the surface of the copper vessel quite bright, by scraping it, and by washing it with a solution of muriate of ammonia: it is then heated, and the tin, or metallic mixture designed for tinning, is melted, and poured into it; and being made to flow quickly over every part of the surface of the vessel, it incorporates with the copper, and, when cold, remains united with it. Rosin or pitch is used, to prevent the tin from being oxidised, and the copper from being scaled; either of which circumstances would hinder the sticking of the tin. Bishop Watson says:—"I had the curiosity to estimate the quantity of pure tin, which is used in tinning a definite surface of copper. The vessel was accurately weighed before and after it was tinned, its surface being equal to 254 square inches; its weight, before tinning, was 46 ounces, and after the operation, it barely weighed 46½ ounces; so that half an ounce of tin was spread over 254 square inches, or somewhat less than a grain of tin upon each square inch of copper. How innocent soever pure tin may be, still the tenuity of its coat in the ordinary way of tinning copper vessels, cannot fail to excite the serious apprehensions of those who consider it; for in the experiment which I have mentioned, the tin was laid on with a thicker coat than in the common way. Instead of a grain, I suspect that not a quarter of a grain of tin is spread over a square inch in the common way of tinning. To prove that a thicker coat might be given, I desired a workman to break off the end of a pair of pincers, which had been long used in taking the plates out of the melted tin; the iron of the pincers seemed to have been penetrated through its whole substance by the tin; it was of a white colour, and had preserved its malleability."

Great care should be taken with all vessels, even when well tinned; not to allow acid substances to remain in them for any length of time, because the tin will become corroded thereby; and part of the copper afterwards dissolving in any future acid or salt liquor, which may be put in such vessels, will render it highly poisonous.

LXXVIII.

METHOD OF COATING IRON WITH ZINC.

The vessels are first made very bright, so that not a black speck can be seen; they are then rubbed with a solution of Muriate of Ammonia, and afterwards dipped into an iron pot full of melted Zinc, and being taken out, the Zinc is found to cover the surface of the Iron. If a thicker coat of Zinc is wanted, it may be obtained by dipping the vessel a second time. This kind of covering is so hard, that the vessels may be scoured with sand without its being rubbed off.

Observation. A discovery has lately been made by a manufacturer at Sheffield, whereby copper vessels may be coated on their insides, by *malleable* zinc.

LXXIX.

PRECIPITATION OF GOLD

From its Solution, by Sulphate of Iron.

If a few drops of solution of Sulphate, or Carbonate of Iron are poured into a solution of Nitro-muriate of Gold, a very beautiful shining yellow precipitate will take place: this precipitate is metallic Gold, which may be saved upon the filter.

Observations. Here the nitro-muriatic acid having greater affinity for iron than gold, leaves the latter to combine with the former, and thus forms a muriate or nitro-muriate of iron, setting the sulphuric acid free.

After the gold is separated, the acid may be proved to exist in the fluid, by pouring in a solution of carbonate of potass. The muriatic acid will combine with the alkali, whilst the carbonic acid is set free with effervescence.

LXXX.

A variation of this experiment may be as follows. First, dip an ivory paper knife into a solution of Sulphate of Iron, and then into a solution of Nitro-muriate of Gold. On withdrawing it from the latter, the part immersed will be found covered with metallic Gold.

Observation. The theory is the same. In this way, china ware or even a piece of white crockery may be gilt, by first drawing a flower or design with the sulphate, and dipping it in the muriate.

LXXXI.

PRECIPITATION OF GOLD UPON CHARCOAL,

By the Action of Light.

Pour ½ an ounce of diluted Nitro-muriate of Gold into an ale glass, and immerse a piece of very smooth Charcoal: expose the glass to the rays of the sun, in a warm place. The Charcoal will very soon be covered over with a beautiful golden coat. It should be taken out with a forceps, dried, and enclosed in a phial for shew.

Observation. In this experiment, it is said that the precipitation of the metal is the consequence of decomposition of the acid by the sun's rays.

LXXXII.

PRECIPITATION OF GOLD UPON CHARCOAL,

From the Nitro-muriate, by heat alone.

Immerse a slip of Charcoal in a phial, containing Nitro-muriate of Gold: expose this to a considerable heat, first gradually, to prevent breaking; and then, either by immersing the phial in a vessel of boiling water, or in a sand bath. In either case the Charcoal will be coated with Gold. Here the assistance of heat alone is required.

LXXXIII.

MODE OF COVERING BARS of COPPER, &c. WITH GOLD

So as to be capable of being rolled out into Sheets.

This method of *Gilding* was invented by Mr. Turner of

Birmingham. Mr. Turner first prepares ingots or pieces of Copper or Brass in convenient lengths and sizes. He then cleans them from impurity, and makes their surfaces level, and prepares plates of pure Gold, or Gold mixed with a portion of alloy, of the same size as the ingots of metal, and of suitable thickness. Having placed a piece of Gold upon an ingot, intended to be plated, he hammers and compresses them both together, so that they may have their surfaces as nearly equal to each other as possible; and then binds them together with wire, in order to keep them in the same position during the process required to attach them. Afterwards he takes Silver filings, which he mixes with Borax, to assist the fusion of the Silver. This mixture he lays upon the edge of the plate of Gold, and next to the ingot of metal. Having thus prepared the two bodies, he places them upon a fire in a stove or furnace, where they remain until the Silver and Borax placed along the edges of the metals melt, and until the adhesion of the Gold with the metal is perfect. He then takes the ingot carefully out of the stove. By this process the ingot is plated with Gold, and prepared ready for rolling into sheets.

Observations. Copper is plated with silver in nearly the same manner. In this case, an ounce of silver is used, to cover 12 ounces of copper. A coat of this sort, on the inside of copper utensils for the kitchen would be much more lasting, and more conducive to health, than tinned copper, the tinning of which is so liable to corrosion.

LXXXIV.

ART OF GILDING COPPER, &c. BY AMALGAM.

Immerse a very clean bright piece of Copper in a diluted solution of Nitrate of Mercury. By the affinity of Copper for Nitric acid, the Mercury will be precipitated: now spread the Amalgam of Gold, rather thinly over the coat of Mercury, just given to the Copper. This coat unites with the Amalgam, but of course will remain on the Copper. Now place the piece or pieces so operated on, in a clean oven or furnace where there is no smoke. If the heat is a little greater than 660°, the Mercury of the Amalgam will be volatilised, and the Copper will be beautifully gilt.

Observations. In the large way of gilding, the furnaces are so contrived, that the volatilised mercury is again condensed, and preserved for further use, so that there is no loss in the operation. There is also a contrivance by which the volatile particles of mercury are prevented from injuring the gilders. In this experiment there is no danger, only it will be necessary to keep as much aloof as possible whilst the mercury is volatilising.

LXXXV.

MODE OF GILDING IRON

Through the medium of a Coat of Copper.

This mode of giving a Gold coat to Iron is certainly very ingenious, as it comprehends several processes and affinities. The Iron bar, instrument or vessel, is first to be made very bright by dipping it in an acidulated liquor, and then rubbed very dry with whiting. Now prepare a solution of Sulphate of Copper, and immerse the Iron in it: in a few seconds the whole will become covered with a very beautiful but thin coat of Copper; so as to appear entirely composed of that metal. The 'Amalgam of Gold is now to be applied as in the last experiment, and put into the furnace, for the separation of the Mercury. When taken out, the Iron will so completely resemble Gold from this thin covering, as to be mistaken by the inexperienced for a mass of that precious metal.

Observations. The mode of gilding silver wire, is by coating a silver rod with gold leaf; and the rod being afterwards drawn into wire, the gold adheres to it; the smallest proportion of gold, allowed by act of parliament, is 100 grains to 5760 grains of silver; and the best double-gilt wire is said to have about twenty grains more of gold to the same quantity of silver. It has been calculated, that when a common gilt wire is flatted, one grain of gold is stretched to the length of above 401 feet, to a surface of above 100 square inches, and to the thinness of the 492090th part of an inch: and M. de Reaumur says, that a grain of gold may be extended to 2900 feet, and cover a surface of more than 1400 square inches; also that the thickness of the gold, in the thinnest parts of some gilt wire, did not exceed the fourteen millionth part of an inch.

The method of extending gold used by the gold-beaters, consists in hammering a number of thin rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold-leaf, it is found that one grain is made to cover 56¾ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows, that the leaf itself is 1-282000 parts of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the irregularities of the newest skins, and not over them. In using old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains.

LXXXVI.

PRECIPITATION OF GOLD FROM THE ETHEREAL SOLUTION BY STEEL.

Pour some of the Ethereal solution of Gold into a wine glass, and dip therein the blade of a new penknife, lancet or razor; withdraw the instrument, and allow the Ether to evaporate. The blade will be found to be covered by a very beautiful coat of Gold. A clean rag, or small piece of very dry sponge, may be dipped in the Ether, and used to moisten the blade, with the same result.

In this case, there is no occasion to pour the liquid into a glass, which must undoubtedly lose by evaporation; but the rag or sponge may be moistened by it, by applying them to the mouth of the phial. This coating of Gold will remain on the Steel for a great length of time, and will preserve it from rusting.

Observation. This is the way in which swords and other cutlery are ornamented. Lancets too are in this way gilded with great advantage, to secure them from rust.

LXXXVII.

PREPARATION OF GOLD POWDER, FOR GILDING.

Gold powder may be prepared in three different ways:—Put into an earthen mortar some Gold leaf, with a little honey, or thick gum-water; and grind the mixture, till the Gold is reduced to extremely minute particles. When this is done, a little warm water will wash out the honey or gum, leaving the Gold behind in a pulverulent state.

Another way, is to dissolve pure Gold, (or the leaf) in Nitro-muriatic acid; and then to precipitate it by a piece of Copper, or by a solution of Sulphate of Iron The precipitate (if by Copper) must be digested in distilled vinegar, and then washed, (by pouring water over it repeatedly) and dried. This precipitate will be in the form of a very fine powder: it works better, and is more easily burnished than Gold leaf ground with honey as above.

The best method of preparing Gold powder, is by heating a prepared Amalgam of Gold, (See Experiment 34.) in an open clean crucible; and continuing the strong heat, until the whole of the Mercury is evaporated; at the same time, constantly stirring the Amalgam with a glass-rod. When the Mercury has completely left the Gold, the remaining powder is to be ground in a Wedgewood's mortar, with a little water, and afterwards dried. It is now fit for use.

Observations. Although the last mode of operating has been here given; the young chemist cannot be too much reminded of the danger attending the sublimation of mercury. In the small way here described, it is impossible to operate without danger; it is therefore better to prepare it according to the former directions, than to risk the health by the latter.

LXXXVIII.

PRECIPITATION OF METALLIC GOLD

From the Nitro-Muriate, on Silk, Satin, Ivory, &c. by Hydrogen Gas.

Immerse a piece of white Satin, Silk, or Ivory in a solution of Nitro-muriate of Gold, (in the proportion of one part of the Nitro muriate to three of distilled water.) Whilst the substance to be gilded is still wet, immerse it in a jar of Hydrogen gas; it will soon be covered by a complete coat of Gold.

Observation. The divisibility of gold by precipitation in this manner is astonishing, for the coating is hardly the 10 millionth part of an inch thick.

LXXXIX.

The foregoing Experiment may be very prettily and advantageously varied as follows:—Paint flowers or other ornaments with a very fine camel hair pencil dipped in the above mentioned solution of Gold, on pieces of Silk, Satin, &c. &c. &c. and hold them over a Florence flask, from which Hydrogen gas is evolved, during the decomposition of water by Sulphuric acid and Iron filings. The painted flowers, &c. in a few minutes, will shine with all the splendour of the purest Gold. A coating of this kind will not tarnish on exposure to the air, or in washing.

Observations. Porcelain is gilded by mixing nitro-muriate of gold, gum water, and pulverised borax. The mixture is laid on by a brush, and the porcelain is burnt in an oven. The gold is thus revived with great splendour. Porcelain and other wares may be platinised, silvered, tinned, and bronzed, in a similar manner.

XC.

REDUCTION OF GOLD TO ITS METALLIC STATE,

By immersing Silk dipped in Phosphoric Ether, in a solution of Nitro-muriate of Gold.

Immerse a white Silk or Satin ribbon in Phosphoric Ether. When the Ether has evaporated, (which will be known by the smoking of the Phosphorus on the ribbon,) immerse it in a wine glass, containing a solution of Nitro-muriate of

Gold. The Gold will be instantly reduced to the metallic state all over the Silk.

XCI.

Reduction of Gold

From the Nitro-muriatic Solution, by Phosphureted Hydrogen Gas.

Draw figures upon a piece of white Silk or Ivory, with a solution of Nitro-muriate of Gold; and in this state expose it to an atmosphere of Phosphurcted Hydrogen gas contained in a jar. Here the Hydrogen, combining with the Oxygen of the Oxide of Gold, leaves the Gold to be reduced to its metallic state, wherever the figures may have been pencilled.

XCII.

Reduction of Gold to the metallic state,

From the Nitro muriate, by Sulphurous Acid Gas.

If flowers, &c. are painted on Satin, Ivory, &c. by a camel's hair pencil dipped in a solution of Nitro-muriate of Gold, as described in the foregoing experiments; and the substance painted be then immersed in a jar of Sulphurous acid gas; the flowers, &c. will appear with all the metallic brilliance of the purest Gold.

Observation. The sulphurous acid gas is converted into sulphuric acid, by abstracting oxygen from the oxide of gold: the metal is thus precipitated quite pure in any form given to it by the pencil.

XCIII.

Reduction of Silver on Silk

Immersed in a solution of Nitrate of Silver, by exposure to Sulphurous Acid Gas.

Paint flowers, &c. on a white silk ribbon, with a camel's hair pencil dipped in a solution of Nitrate of Silver: immerse this whilst wet in a jar of Sulphurous acid gas, by burning Sulphur under a jar of atmospheric air. The pencilling will assume a beautiful metallic brilliance.

XCIV.

Precipitation of Metallic Silver

From the Nitrate upon Silk, by exposure to a stream of Hydrogen Gas.

Immerse a white silk ribbon in a diluted solution of Nitrate of Silver, and expose it whilst wet to a stream of Hydrogen gas; the Silver will be reduced to a metallic state on the silk. If flowers or figures are painted on Silk with this solution, and the Silk be immersed in distilled water, they will be completely silvered over when exposed to a stream of this gas.

Observation. A similar brilliant effect will follow the reduction of silver, by submitting the pencilled spot to phosphureted hydrogen gas, and phosphoric ether.

XCV.

METALLIC WATERING;

Or, Fer blanc Moiré.

This is an article of Parisian invention, much employed to cover ornamental cabinet work, dressing boxes, telescopes, opera glasses, &c. &c. and is prepared in the following manner.

Sulphuric acid is to be diluted with from seven to nine parts of water, then dip a sponge or rag into it, and wash with it the surface of a sheet of Tin. This will speedily exhibit an appearance of crystallization, which is the Moiré.

This effect however cannot be easily produced upon every sort of sheet Tin, for if the sheet has been much hardened by hammering or rolling, then the Moiré cannot be effected until the sheet has been heated so as to produce an incipient fusion on the surface, after which the acid will act upon it, and produce the Moiré. Almost any acid will do as well as the Sulphuric, and it is said that the Citric acid dissolved in a sufficient quantity of water, answers better than any other.

Observations. The moiré has of late been much improved by employing the blow pipe, to form small and beautiful specks on the surface of the tin, previous to the application of the acid.

When the moiré has been formed, the plate is to be varnished and polished, the varnish being tinted with any glazing colour, and thus the red, green, yellow, and pearl coloured moirés are manufactured.

XCVI.

ART OF PLATING LOOKING GLASSES.

This art is erroneously termed *Silvering*, for, as will be presently seen, there is not a particle of Silver present in the whole composition.

On Tin-foil, fitly disposed on a flat table, Mercury is to be poured, and gently rubbed with a hare's foot; it soon unites itself with the Tin, which then becomes very splendid, or, as the workmen say, is *quickened:* a plate of glass is then door work. Its disadvantage is, that it cannot be burnished, and therefore wants the high lustre produced by the following method.

XCVIII.

ART OF GILDING, BY BURNISHING.

This operation is chiefly performed on picture frames, mouldings, beadings and fine stucco work. The surface to be gilt must be carefully covered with a strong size, made by boiling down pieces of white leather, or clippings of parchment, till they are reduced to a stiff jelly; this coating being dried, eight or ten more must be applied, consisting of the same size, mixed with fine Paris-plaster or washed chalk; when a sufficient number of layers have been put on, varying according to the nature of the work, and the whole is become quite dry, a moderately thick layer must be applied, composed of size and Armenian bole, or yellow Oxide of Lead: while this last is yet moist, the Gold leaf is to be put on in the usual manner; it will immediately adhere on being pressed by the cotton ball, and before the size is become perfectly dry, those parts which are intended to be the most brilliant are to be carefully burnished by an agate or a dog's tooth fixed in a handle.

Observations. In order to save the labour of burnishing, it is a common, but bad practice, slightly to burnish the brilliant parts, and to deaden the rest by drawing a brush over them dipped in size: the required contrast between the polished and the unpolished gold is indeed thus obtained; but the general effect is much inferior to that produced in the regular way, and the smallest drop of water falling on the size part occasions a stain. This kind of gilding can only be applied on in-door work, as rain, and even a considerable degree of dampness, will occasion the gold to peel off. When dirty, it may be cleaned by a soft brush, with hotspirit of wine, or oil of turpentine.

It may be here remarked generally, that for various species of gilding, an article known by the name of Orsidue, Dutch metal, Dutch Leaf and Dutch Foil is very frequently used. But the substances so gilt are not required to retain their brilliancy for any length of time. But when they are required to stand some time they are generally varnished to protect this compound metal from the action of the air. The composition of this Imitation of gold leaf is not generally known; but there is good reason to believe, that it is extensively manufactured in England, as hundreds of tons have been exported to India, to ornament the dresses of the females, dancing girls, priests and deities of that country, also to decorate the Hindu temples. In England and elsewhere, it is used by the Jews, to gild picture frames: likewise by the lower class of bookbinders and painters, in coarse gilding. It is also put on ribbons, and on toys, dolls and gingerbread for children: but the use of this poisonous material for gilding gingerbread and sweetmeats, cannot be too much reprobated. This leaf is certainly serviceable for coarser gilding, where larger masses are wanted, especially where it is to be seen by artificial light, as in the case of theatres; and if well varnished, will there, in a great measure answer the end of the genuine gold leaf.

XCIX.

ART OF GILDING WRITINGS, DRAWINGS, &c.

On Paper and Parchment.

Letters written on vellum or paper are gilded in three ways: in the first, a little size is mixed with the ink, and the letters are written as usual; when they are dry, a slight degree of stickiness is produced by breathing on them, upon which the Gold leaf is immediately applied, and by a little pressure may be made to adhere with sufficient firmness. In the second method, some white-lead or chalk is ground up with strong size, and the letters are made with this by means of a brush: when the mixture is almost dry, the Gold leaf may be laid on, and afterwards burnished. The last method is, to mix up some Gold powder with size, and to form the letters of this, by means of a brush.

Observation. It is supposed that this latter method was that used by the monks in illuminating their missals, psalters and rubrics.

C.

ART OF GILDING THE EDGES OF PAPER.

The edges of the leaves of books and letter paper, are gilded, whilst in an horizontal position in the bookbinder's press, by first applying a composition formed of four parts of Armenian bole, and one of candied sugar, ground together with water to a proper consistence, and laid on by a brush with the white of an egg. This coating, when nearly dry, is smoothed by the burnisher; which is generally a crooked piece of agate very smooth, and fixed in a handle. It is then slightly moistened by a sponge dipped in clean water, and squeezed in the hand. The Gold leaf is now taken up on a piece of cotton from the leathern cushion, and applied on the moistened surface. When dry it is to be burnished by rubbing the agate over it repeatedly from end to end, taking care not to wound the surface by the point of the burnisher. A piece of silk or India paper is usually interposed between the Gold and the burnisher.

Observation. Cotton wool is generally used by bookbinders to take the leaf up from the cushion; being the best adapted for the purpose, on account of its pliability, smoothness, softness, and slight moistness; the latter of which properties it either possesses naturally, or else it is given to it by rubbing against the forehead:—a very common practice with bookbinders.

CI.

ART OF GILDING LEATHER.

In order to impress gilt figures, letters, and other marks upon leather; as, on the covers of books, edgings for doors, &c.: the leather must first be dusted over with very finely powdered yellow rosin, or mastich gum. The iron tools or stamps are now arranged on a rack before a clear fire, so as to be well heated, without becoming red hot. If the tools are *letters*, they have an alphabetical arrangement on the rack. Each letter or stamp must be tried as to its heat, by imprinting its mark on the raw side of a piece of waste leather. A little practice will enable the workman to judge of the heat. The tool is now to be pressed downwards on the Gold leaf; which will of course be indented, and shew the figure imprinted on it. The next letter or stamp is now to be taken and stamped in like manner, and so on with the others; taking care to keep the letters in an even line with each other, like those in a book. By this operation, the resin is melted; consequently the Gold adheres to the Leather; the superfluous Gold may then be rubbed off by a cloth; the gilded impressions remaining on the Leather. In this as in every other operation, adroitness is acquired by practice.

Observations. The cloth alluded to should be slightly greasy, to retain the gold wiped off; (otherwise there will be great waste in a few months), the cloth will thus be soon completely saturated or loaded with the gold. When this is the case, these cloths are generally sold to the refiners, who burn them and recover the gold. Some of these afford so much gold by burning, as to be worth from a guinea to a guinea and a half.

CII.

ART OF GILDING GLASS AND PORCELAIN.

Drinking, and other glasses are sometimes gilt on their edges. This is done, either by an adhesive varnish, or by heat. The varnish is prepared by dissolving in boiled linseed oil, an equal weight either of copal or amber. This is to be diluted by a proper quantity of oil of turpentine, so as to be applied as thin as possible to the parts of the glass intended to be gilt. When this is done, which will be in about 24 hours, the glass is to be placed in a stove, till it is so warm as almost to burn the fingers when handled. At this temperature, the varnish will become adhesive, and a piece of leaf Gold applied in the usual way will immediately stick. Sweep off the superfluous portions of the leaf; and when quite cold, it may be burnished, taking care to interpose a piece of very thin paper (India paper) between the Gold and the burnisher. If the varnish is very good, this is the best method of gilding glass, as the Gold is thus fixed on more evenly than in any other way: it often happens, however, when the varnish is but indifferent, that by repeated washing the Gold soon wears off: on this account the practice of burning it in, is sometimes had recourse to.

For this purpose, some Gold powder is ground with Borax, and in this state applied to the clean surface of the glass, by a camel's hair pencil; when quite dry, the glass is put into a stove heated to about the temperature of an annealing oven; the gum burns off, and the borax, by vitrifying, cements the Gold with great firmness to the glass; after which it may be burnished.

Observation. The gilding upon porcelain is in like manner fixed by heat and the use of borax; and this kind of ware being neither transparent nor liable to soften, and thus injure its form in a low red heat, is free from the risk and injury which the finer and more fusible kinds of glass are apt to sustain from such treatment.

CHAPTER III.

EXPERIMENTS ON THE SEPARATION OF METALS AND OTHER SIMPLE BODIES, FROM THEIR NATURAL OR ARTIFICIAL COMBINATIONS.

CIII.

Reduction of Metals in general, *From their Oxides.*

MIX an ounce of any metallic Oxide to be reduced, with an ounce of Charcoal powder, making a paste with Oil; (but this is not always necessary;) put the whole into a crucible, and submit it to a strong heat: if the metal be volatile, (as Arsenic,) another crucible is to be inverted over the one containing the compound; or the crucible should have a lid luted on. The metal will be found at the bottom of the crucible in the form of a button.

Observations. In all cases of reduction of metallic oxides, the charcoal (or whatever substance is heated with the oxide,) combines with the oxygen of the oxide, and flies off in the state of carbonic acid gas; and the metal being left free, falls to the bottom of the crucible. For this reason charcoal is called a flux; the meaning of which is, that it causes the metal to flow from the oxide; but the word does not convey a correct idea of its office. In the large way small coals are mixed with metallic ores, the whole is submitted to great heat in a furnace, and when the metal is reduced, it is allowed to run off by an aperture, as beer does from a barrel.

CIV.

Metallic Lead obtained from its Oxides.

Put four ounces of red Oxide of Lead with one ounce and a half of Charcoal powder into a crucible; stir them well together with a stick, so that the colour of the mixture may be a dirty brown. Put the crucible into a good fire, and give it a red heat for a quarter of an hour; when sufficiently heated, pour the contents of the crucible into any mould; the Lead will run from under the powder on the top. Here, the Oxygen with which the metal had been combined, leaves it, to attach itself to the Charcoal, with which it forms Carbonic acid Gas: the Gas flies off; and the Lead from being most entirely insoluble in it. There is somewhat more difficulty in depriving the green sediment of oxalate of nickel of every atom of cobalt. To effect this, it must be dissolved, as at first, with pure ammonia, exposed to the air till the green sediment has separated, and then rinsed with hot water, the water containing the cobalt, becoming slightly rose-coloured, and the insoluble oxalate of nickel becoming of a purer green. A repetition of this operation two or three times, will separate every atom of the oxalate of cobalt.

At first we employed concentrated ammonia, which made the experiments rather expensive, but we found that a more dilute ammonia would answer as well. The mixed oxalates of cobalt and nickel should be rubbed with it in a mortar, and the whole should then be poured into a phial, and frequently shaken till the solution is complete, which may be assisted by a gentle heat. When the ammonia is concentrated, the colour is violet; but blue, when more dilute. This, by exposure to air, produces, as above described, the deep red solution of oxalate of cobalt, which, by slow evaporation, crystallizes in fine garnet-coloured needles, which are readily soluble in water, but more so when heated. Ammonia also dissolves these crystals, both warm and cold, and the solution does not deposit an atom of nickel, which is a mark of its purity.

When this oxalate of cobalt is calcined, it leaves a deutoxide which dissolves in strong muriatic acid, with disengagement of chlorine. The solution at first is green, as if it contained iron or nickel, but this colour is only owing to the admixture of the yellow of the chlorine with the natural blue of the pure muriate of cobalt; and accordingly the liquid becomes of a very pure blue, as soon as all the cobalt has been brought to the state of protoxide, and the chlorine is expelled. If the blue muriate is exposed to the air for several days, the excess of acid is dissipated, the colour deepens to violet, and in time would probably become red, as happens when water is added.

On the other hand, when the solution is concentrated by a gentle heat, it takes a pure blue colour, and leaves a residue of the same; which, on the addition of a little water, forms a rose-coloured solution. This again becomes blue when heated, and much concentrated, and then crystallizes spontaneously into beautiful ruby-coloured prisms. These crystals of muriate of cobalt are not deliquescent if pure, nor does the mother-liquor yield a deliquescent salt, unless the air is extremely moist, or unless any nickel is present; but if this occurs, the liquor becomes green. It is, therefore, to the presence of nickel that the supposed deliquescence of muriate of cobalt is to be attributed.

It appears, therefore, from these experiments, that cobalt and nickel brought to the state of oxalate, and treated by ammonia either concentrated or diluted with two parts of water, may be separated from each other; and we conceive that the following is the explanation of what takes place:—these two oxalates are changed by solution in ammonia into triple salts of oxalic acid, ammonia and the metallic oxide. What proves it, is, that after their extraction and separation, they both give out ammonia by the addition of potass. But the ammoniacal oxalate of nickel which dissolves so well in ammonia, is quite insoluble in water; and on the other hand, the corresponding salt of cobalt dissolves readily both in ammonia and in water. Hence, in proportion as the excess of ammonia evaporates by exposure of the compound solution to the air, the first precipitate that falls down is the triple salt of nickel; whilst the salt of cobalt remains till the further evaporation of the mere water necessary to its solution. Therefore, it is of advantage not to wait too long before the first deposit is removed.

As a proof that it is the excess of ammonia which holds the oxalate of nickel in solution, it may be added, that the compound solution will remain unchanged for months in a vessel hermetrically sealed; or if they crystallize, it is in mass, and without any visible separation of one salt from the other.

CVI.

PROCESS FOR OBTAINING PURE NICKEL.

The following process is recommended by Dr. Thomson, for procuring pure Nickel:—" I take a quantity of the brittle reddish alloy, well known in commerce by the name of *Speiss*. This alloy is chiefly an Arseniuret of Nickel, though it probably contains also, occasionally at least, several other metals. Upon the speiss reduced to a coarse powder, I pour a quantity of diluted Sulphuric acid, place the mixture in a Wedgewood evaporating dish upon a sand bath, and add the requisite quantity of Nitric acid at intervals, to enable the acid to act upon the speiss. By this process, I obtain a deep grass-green liquid, while a considerable quantity of Arsenious acid remains undissolved. The green liquid, carefully decanted off the Arsenious acid, is evaporated on the sand bath, till it is sufficiently concentrated to yield crystals. It is then set aside in a cool place. A deposit of beautiful crystals of Sulphate of Nickel is obtained. By concentrating the liquid still further, more crystals of Sulphate of Nickel fall, but after a certain time, the liquid, though its colour continues still a dark green, refuses to yield any more crystals of Sulphate of Nickel. By evaporating it to the required consistency, and then setting it aside, a very abundant deposit is made of an apple-green salt, which adheres very firmly to the evaporating dish. I took this matter at first, from its colour, to be Arseniate of Nickel; but I found it, on examination, to be a double salt, consisting of Sulphate of Nickel and Arseniate of Nickel, united together. I endeavoured to get rid of the Arsenic acid by dissolving the salt in water, and causing a current of Sulphuretted Hydrogen gas to pass through it, as long as any precipitate appeared. By this method I threw down a great deal of Arsenic, but on filtering and evaporating the liquor, it was still converted into an apple-green matter, and, of course, contained Arsenic. I found that when the salt was dissolved in water, the liquid became opaque, owing to a quantity of Arsenious acid, which separated from the salt. The liquid being now filtered, (to get rid of the Arsenious acid,) and properly evaporated, yielded a new crop of crystals of Sulphate of Nickel. These crystals continued to be deposited as long as a single drop of the liquid remained unevaporated. By this method may the whole of the Nickel in the speiss be obtained in the state of Sulphate of Nickel. This Sulphate is quite free from Arsenic or Arsenious acids, for the presence of these acids prevents Sulphate of Nickel from crystallizing. But for greater security I dissolve the Sulphate of Nickel in water, and crystallize a second time.

The pure Sulphate of Nickel thus obtained, is dissolved in water, and decomposed by Carbonate of Soda. The Carbonate of Nickel, when well washed and dried, is a light-green powder. I make it up into balls with a little oil, and enclose them in a Charcoal crucible, which is put into a Hessian crucible, the mouth of which is covered and luted. It is now exposed to the greatest heat that I can raise in a melting furnace, for two hours. By this process I have always obtained a button of pure Nickel in the metallic state.

The Nickel thus obtained is hard, but malleable, and very obedient to the magnet. I think it contains a certain proportion of Carbon in combination with the Nickel. The button is usually surrounded by a thin dark shining cuticle, which I take to be a Carburet of Nickel."

CVII.

TO OBTAIN SILVER IN A STATE OF PURITY.

Pour over a Shilling, Half-crown, or even filings or clippings of Silver, as much Nitric acid, diluted with water, as will dissolve them. Into this solution, repeatedly immerse a plate of polished Copper, as long as a precipitation of metallic Silver takes place. After each immersion, wipe the precipitate off on paper, by means of a feather. Some of the precipitate will fall to the bottom of the vessel; the liquid must accordingly be poured off, and both precipitates put on a filter; and distilled water poured over them to wash away the Nitric acid, &c.

This powder is now to be boiled in a solution of pure Ammonia, in a Florence flask, placed over a lamp, to dissolve any Oxide of Copper which may be precipitated with the Silver; this alkaline solution will accordingly have a blue tinge. Now filter and precipitate, as before, and pour distilled water over the powder to wash away any remnant of Ammoniuret of Copper. If the Silver is now put into a clean crucible and heat be applied, it may be obtained in a mass, either by moulding or otherwise.

To obtain pure Silver from Luna Cornea, or fused Muriate of Silver, put into a clean crucible one ounce of this substance, and when in a state of fusion, mix with it three ounces of Carbonate of Soda, deprived of its water of crystallization: submit them to a good heat; when the whole has been fused, let the mixture cool; and when cold, let it be broken; the Silver (about six drachms in weight) will be found in a metallic state.

Observations. The Persian mode of purifying silver is as follows;—it was related and illustrated in the Laboratory of the Royal Institution, by Oostad Muhammed Ali. A sort of basin is made, either by excavating the ground, or by arranging stones in a circle. This is from nine to twelve, or fourteen inches wide, and is incomplete at the side, in one place, for the reception of the fuel, which, by its combustion, is to melt the metal. The fuel consists of two large and long logs of wood, which are placed with their ends in the aperture on the edge of the basin. These ends are lighted by putting a little burning fuel on them, and then the blast from a pair of bellows is directed to, and over the fire, so as to direct the flame and heat into the basin, in the manner indeed, of a large blow-pipe. Lead, containing silver, or impure silver with lead, is then placed in the basin, which being soon melted and heated by the flame, is purified as by common cupellation. The litharge is forced off to the sides as it is formed, and is either absorbed or lost. As the wood burns away before the jet of air, the logs are thrust onwards, until all is consumed; then fresh logs are applied, if necessary, or the process is stopped, as may be found expedient.

CVIII.

TO OBTAIN CHROMIUM FROM CHROMIC ACID.

Make a paste of four drams of the dry crystals of Chromic Acid, eight drams of Charcoal, and four drams of Oil. Put the paste into a crucible, and submit it to a considerable heat. The Oxygen of the acid will, with the Charcoal and Oil, form Carbonic Acid, and the metal will be reduced at the bottom of the crucible. Chromium is a brittle light metal, of a greyish lustre.

Observation. One of the most important of the metalliferous substances met with by Doctor Hibbert of Manchester, in his recent tour through the Shetland Isles, was that very valuable one the granular *chromate of iron*, which he found in masses of considerable size. This mineral, in those countries where it is found in quantities, is employed to furnish the chromic acid, which, when united to the oxide of lead, forms chromate of lead, a very beautiful and much esteemed yellow pigment.

CIX.

To procure Antimony from the Sulphuret.

Powder the Sulphuret in an iron-mortar, and submit it to considerable heat in a crucible, to drive off the Sulphur. Then mix it with its own weight of black flux, and again give it a strong heat. A button of Antimony will be found at the bottom of the crucible. Pure Antimony shines like Silver. Its specific gravity is 6.800.

Observations. Antimony is found, native and combined, in many countries of Europe. Alloyed with other metals, it forms a part of bell-metal, and printers' types. Preparations of it are used in Medicine. It is said, that when mixed with the food of pigs, it not only removes disease from these animals, but that it also fattens them. Basil Valentine, a German monk, knowing this circumstance, administered it to some of his brotherhood in the convent; but instead of being fattened by it, they died.

CX.

To purify Copper.

Pour some diluted Nitric Acid over some filings of Copper, in a decanting glass, and make a saturated solution by pouring in more acid, if required, or putting in more Copper if the acid will dissolve it. Now immerse pieces of Iron, until precipitation ceases, and wipe the metallic Copper off into the liquid as fast as it is generated. When no more will precipitate, allow the liquid to settle, and decant it when clear: pour more water on the precipitate to wash it. Now put it into a crucible and submit it to a strong heat. A button of very pure Copper will be found at the bottom. A similar precipitation may be made from a solution of Sulphate of Copper.

Observations. Copper is procured from its ore in the Isle of Anglesey, in the following manner:—The ore is first broken in small pieces, and then piled up in heaps between two walls, twenty, thirty, or fifty yards in length, and covered over with flat stones, which are cemented together. The heaps are then set on fire, and the sulphur is sublimed in chimneys made for that purpose, and preserved for sale. These heaps continue three or four months burning, according to their size; some are so large (about two thousand tons in weight) as to require ten months. The ore being now reduced in weight, is washed. The water of which washing being a solution of sulphate of copper, is precipitated by all sorts of old iron.

Pure copper is generally obtained by using the solution of sulphate of copper which is lodged at the bottom of a bed of ore in a copper mine. This solution is drawn up and poured into pits where all kinds of old iron are thrown. The iron attracts the sulphuric acid, and is thus in time dissolved; but a thick crust of metallic copper is first precipitated on it. This is scraped off and fused: the iron is then thrown in again to precipitate more. This is repeatedly done until the iron is entirely wasted; that is, dissolved by the sulphuric acid. Precipitation of copper on iron in the large way, is also practised in Ireland and Hungary. The purest copper is always obtained in this way.

Native copper is generally found in Siberia. An entire mass has been found in the Brazils, weighing 2,666 pounds. It is now in Lisbon. A large mass was also recently found in the bed of the river Onatanagan, in the United States of America. Notwithstanding the number of copper mines, particularly in Wales, till about the year 1730, most of the copper and brass utensils for culinary and other purposes used in this country, were imported from Hamburgh and Holland, being procured from the manufactories of Germany; even so late as the year 1750, copper tea-kettles, saucepans, and pots of all sizes were imported in large quantities; but through the persevering industry and enterprising spirit of our miners and manufacturers, these imports have become totally unnecessary. The discovery of the new copper mines in Derbyshire and Wales about the year 1773, contributed to the extension of the manufacture in this country, and it is calculated that the annual value of the exports of copper and brass is not less than 3.500,000l. and that the number of persons employed in the different branches and stages of these manufactures is not less than 6000. One of the richest lodes of copper that has been seen for many years past, has lately been discovered in the neighbourhood of Padstow in Cornwall; it is a fine grey ore, three feet thick, and worth from 80 to 100l. per fathom, and is only fifteen feet below the surface of the earth, while the levels are such as to admit with ease of an adit at forty fathoms. Rocks of grey ore are to be seen on the spot, of two cwt. each, and worth 40l. per ton. Very extensive mines of copper have lately been discovered in different parts of Ireland, which bid fair to become a source of great wealth to that country. In the county of Wicklow, there is an extent of country nearly ten miles in length, (reaching from the mountain in which gold has been found, from N. W. to S. E.) in which distinct veins of copper have been discovered. Copper ore of a very rich quality has also been discovered in the county of Wexford. The hills of Allen, of Kills, and of Killmarny contain several valuable veins.

Copper, both in its native and combined states, likewise the ores and salts of other metals, may be gratuitously viewed at all times in the great Saloon of the British Museum; where they are arranged in glass cases, according to a generic plan, thus *Salts of Copper*, *Salts of Silver*, *Salts of Lime, &c. &c. &c.* The arrangement and magnificence of the whole, whilst they do honour to the science of the country, reflect great credit on the judgement of the managers. Specimens of almost all these minerals, in a state of great perfection, form also an important part of the Mineralogical and Geological collections sold by Mr. Mawe, in the Strand, London. Mr. Mawe is in possession of a piece of pure native gold, partly combined with pieces of silex. This specimen, which he found whilst travelling in the Brazils, is much worn by rolling in a river, perhaps for many ages. It contains now, as much pure gold as may be coined into 30 guineas.

Copper exists in considerable abundance in nature; it is found native; alloyed with other metals; combined with sulphur; in the state of oxide; and in that of salt. It is not unfrequently met with in the native state, sometimes crystallized in an arborescent form, and sometimes in more regular figures. Copper exists native, alloyed with gold and silver. The most abundant ores of copper are the sulphurets, and of these there are a considerable variety, exhibiting various colours, and various forms of crystals. In the state of oxide it has been found in Peru of a greenish colour mixed with white sand. In the state of salt, copper is combined with the sulphuric and carbonic acids, forming native sulphates and carbonates of copper.

CXI.

To obtain pure Iron from Cast Iron.

Cast Iron is a compound of Iron, Charcoal, and Oxygen. To free it from the two latter, the cast Iron must be fused with its weight of quick Lime in a strong crucible. It should be frequently stirred up. The pure malleable Iron will be found at the bottom. The heat must be 150 degrees of Wedgewood. The Charcoal or Carbon of the cast Iron combines with the Oxygen of the atmosphere and of the Iron, forming Carbonic Acid, which attaches itself to the Lime, forming Carbonate of Lime, and thus the pure Iron is set free.

Observations. In the large way, the crude or cast iron is introduced into a furnace, where it is melted by the flame of combustibles, which is directed to its surface; and while it is in a state of fusion it is constantly stirred, that it may be brought uniformly in contact with the air. At last it swells, and gives out a blue flame, and when this is continued for about an hour, the iron begins to acquire consistency, and at last becomes solid. Whilst it is hot, it is removed from the furnace, and hammered and rolled by the action of machinery. It is then pure iron, of the specific gravity of 8.000. This is what is ordinarily termed *pure iron,* though it really still contains a small portion of *carbon*. Mr. Jennings, the patentee of the new Mariner's Compass, is the only chemist who has obtained it in the state of absolute purity; it will not, then, give fire when struck with flint. His process is not accurately known.

Native iron has been found in many parts of the world. The new nation lately discovered by Captain Ross, were in the habit of using knives and spears struck off from an immense piece of native iron, which lay on the ground. These instruments, from the uncivilised state of the poor inhabitants, were not forged, but struck into something like shape, by hammering them with stones. This proves the iron to be pure. In the Petersburgh Museum, there is a piece of native iron, which weighs upwards of 1,200 pounds.

A mass of native iron was discovered in the Brazils in 1784. It is about seven feet long, four wide, and two thick; but of an irregular shape. Mr. Murray calculates its weight 14,000 pounds. It exhibited a crystalline structure, and was disposed to break in octahedrons, tetrahedrons, or the rhomboids formed by their junction. It was magnetic by induction, like common iron; and composed of ninety-six parts of iron, with four parts of nickel. These masses are supposed to have been of meteoric origin. Iron and nickel are always found to be components of meteoric stones.

A mass of native iron, weighing upwards of three thousand pounds, discovered several years ago on the banks of Red River in Louisiana, is now in the collection of the Historical Society in the New York Institution. Its shape is irregular, inclining to oviform; its surface deeply indented, and covered by an oxide of iron, and it is much broader at the bottom, where it has rested on the earth, than at the top, inclining somewhat in the manner of a cone. By several experiments which have been made upon different pieces of it, there appears to be a want of uniformity in its quality, some parts being very malleable and ductile, while others possess nearly the hardness of steel. It is susceptible of the highest polish, and is said to contain some nickel. This mass of iron was found about one hundred miles above Natchitoches, on Red River, on one of those rich and extensive prairies so common to that part of the country; and about twelve miles from the banks of the river.

Iron and copper are both very apt to be scaled by heat, and thereby lose greatly in weight. 24 cwt. of pure plate copper will not, when manufactured into tea-kettles, pans, &c. give above 23 cwt. 21 cwt. of bar iron will give a ton, when split into rods; but taking into consideration all iron and steel wares, from a needle to an anchor, it is estimated that 30 cwt. of bar iron will, at an average, yield a ton of wares.

30 cwt. of cast iron is reduced to 20, when it is to be made into wire; and 26 to 22, when it is to be made into bar iron. Steel suffers much less loss of weight in being hammered, than iron does. Cast steel does not lose above two parts, and bar steel not above 4 in 100, when drawn into the shape of razors, files, &c.

CXII.

To REDUCE ZINC FROM ITS ORES.

Mix two ounces of powdered Calamine Stone (which is partly an Oxide and partly a Carbonate of Zinc) with an ounce and a half of powdered Charcoal and half an ounce of quick Lime. Let the mixture be rammed into a crucible, and submitted to a strong heat: the metal will be reduced, and may be run into a mould. Here the Charcoal combines with the Oxygen of the Oxide to form Carbonic acid, which flies off; and the Lime at the same time combining with the Carbonic acid of the Carbonate, leaves the Zinc in its metallic state.

Observations. Zinc bears a great resemblance to lead; only, that it is more hard and sonorous, and less malleable in the common way of working: but a Sheffield manufacturer has lately proved that this metal can be drawn into wire, and rolled into sheets of from 24 to 30 inches wide, and from 6 to 8 feet long, from which sheets, it is manufactured into pipes for steam, warm air, rain water, and underground conveyance; as well as into pumps, milk bowls, linings for cisterns and a very great variety of other articles. Zinc does not melt so easily as tin or lead, but more easily than silver or copper. In a degree of heat just sufficient to melt it, it burns away into a kind of grey ash without being inflamed; and in a stronger heat it burns with a yellowish blue or green flame, resolving itself into a white earth, which is driven off by the violence of the fire during the combustion, or remains surrounding the burning zinc like a piece of cotton wool. This combustion of zinc is as striking an experiment as any in chemistry, and it is in the power of any person to make it, by sprinkling filings of zinc on a pan of burning charcoal, or on a poker, or other piece of iron heated to a white heat; it is this property which renders fine filings of zinc of great use in fire-works. Zinc is a very singular metallic substance: it not only burns when sufficiently heated, with a vivid flame, but it yields an inflammable air by solution in sulphuric acid and muriate of soda, and even in some of its ores it manifests a phosphoric quality. A piece of black jack from Freiburg, being scratched in the dark with the finger nail, emitted a strong white light.

Calamine is found in most parts of Europe; we have great plenty of it in Somersetshire, Flintshire, Derbyshire, and in many other parts of England It is scarcely to be distinguished by its appearance from some sorts of lime-stone; for it has none of the metallic lustre usually appertaining to ores: it differs, however, by its weight from every sort of stone; it being, bulk for bulk, nearly twice as heavy as either flint or lime-stone. Before the reign of Elizabeth this mineral was held in very little estimation in Great Britain; and even at so late a period as towards the end of the 17th century, it was commonly carried out of the kingdom as ballast by the ships which traded to foreign parts, especially to Holland.

A very valuable mine of this mineral was some years ago discovered at Craven, Yorkshire, where formerly there were copper mines. It is found in strata, at the bottom of caverns, about eight fathoms from the surface, in some places six feet thick. One of the caverns is one hundred and four yards, another eighty-four, a third forty yards in length, and about fourteen yards wide. It is supposed to have been sublimed by a volcano, as the stones surrounding it have been vitrified.

Dr. Watson, late Bishop of Landaff, thus describes the distillation of zinc *per decensum*, as performed at the Henham copper works near Bristol. In a circular kind of oven, like a glass-house furnace, there were placed six pots about four feet each in height, much resembling large oil jars in shape; into the bottom of each pot was inserted an iron tube, which passed through the floor of the furnace into a vessel of water. The pots were filled with a mixture of calamine and charcoal, and the mouth of each was then close stopped with clay. The fire being properly applied, the metallic vapour of the calamine issued through the iron tube, there being no other place through which it could escape, and the air being excluded, it did not take fire, but was condensed into very small particles in the water, and being remelted was formed into ingots, and sent to Birmingham under the name of zinc or spelter. This zinc will be more or less pure, according as the calamine is free from, or mixed with iron, lead, copper, or other metallic substances.

Brass is a compound of zinc and copper. As the ancients did not know the metal itself, (having never been found native,) they made brass and bronze by mixing calamine with charcoal and copper, and submitting them to heat. They supposed, that the changes of colour, additional weight, and greater durability, were occasioned by a combination of *Earth* (oxide) with the copper: they also supposed that the copper was thus purged of its impurities. Zinc plates placed alternately with copper ones, are used in galvanic troughs. The Chinese use very pure zinc as coin, which having holes in the centre, they carry on strings, like beads.

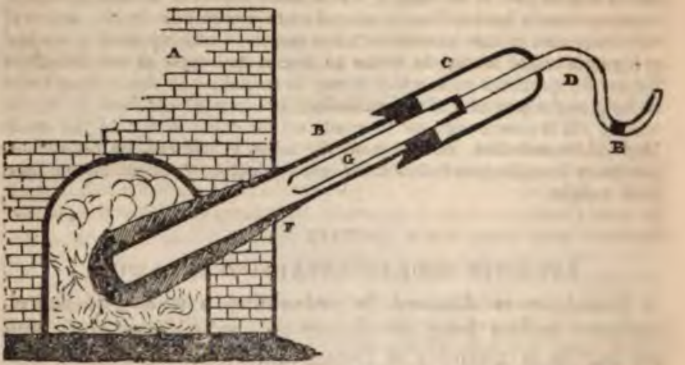
In the great works where calamine is prepared for the brass makers, it is first properly calcined, by which process it loses between a third and a fourth part of its weight; it is next carefully picked, (the heterogeneous parts having been rendered more discernible by the action of the fire;) and is then ground to a fine powder: afterwards it is washed in a gentle rill of water, in order to free it as much as possible from the earthy particles with which it may be mixed;—for these, being twice as light as the particles of the calamine, are carried off from it by the water. It is now ready to be made up for sale. A ton of the crude Derbyshire calamine, as dug from the mine, is reduced, by the various processes it undergoes before it becomes saleable, to about twelve hundred weight.

CXIII.

IMPROVED MODE OF OBTAINING POTASSIUM.

Potassium is obtained by imbedding a wide gun-barrel, eighteen inches long, in a lute of Stourbridge-clay, and putting in a quantity of Potass and Iron-filings, free from impurity: a smaller barrel, eight inches long, is then to be inserted in the large one. This small one must be open at the top, and have a small aperture at the bottom for admission of the Potassium in a state of vapour as it is sublimed from the large barrel: it should also have its upper end an inch higher up than the large one, for the convenience of withdrawing it when the process is finished. The interstices between the tubes should be made air-tight: and the smaller one should be plugged with a cork, through which a crooked glass tube containing a globule of Mercury may pass. The Mercury will shew by its motion that the apparatus is perfectly air-tight: an iron cap should cover the mouths of the barrels; but should have a perforation in the top for transmission of the glass tube containing the Mercury. The apparatus may now be plunged into a furnace or blacksmith's forge, and kept in a white heat for an hour: at the same time keeping the part of the barrels not in the fire perfectly cool, by wrapping the part not luted with linen, which should be kept constantly moist.—On separating the apparatus, a greater quantity of Potassium (of proper lustre,) than can be obtained by any other method, will be found within the internal tube.

Observation. The following is a figure of the apparatus.



A, is the furnace; B, the tube containing potass; C, the cap of iron to prevent the escape of the potassium; D, a bent glass tube, having a globule of mercury (E) to prevent the escape of potassium in the state of vapour: F, fire lute, to prevent the fusion of the metallic tube, G, the tube, containing potassium.

The above-mentioned method for obtaining potassium, was invented by the late Mr. Smithson Tennant.

CXIV.

TO OBTAIN PURE PLATINUM.

A new method of purifying Platinum has been discovered by the Marquis of Ridolfi, calculated to diminish the price of that most useful metal. His process is as follows:—Separate from crude Platina, such foreign bodies as can be detected by the eye, and wash the remainder in diluted Muriatic Acid. Now fuse it with four times its weight of Lead, and throw the melted Alloy into cold water. The Alloy is then to be pulverised in an iron mortar, and mixed with an equal weight of Sulphur. Now throw the mixture into a Hessian crucible, previously heated to whiteness, and put on a lid or cover. Keep the whole in a red heat for ten minutes. When cold, a brilliant metallic button, containing Platinum, Lead, and Sulphur, will be found under the scoriæ. To this, add a little more Lead and fuse again. The Sulphur will now separate from the scoriæ, and an Alloy of Platinum and Lead will be found at the bottom. Heat this button to whiteness, and in this state, strike it on an anvil with a hot hammer, till the whole of the Lead is pressed out.

Observations. Platinum thus prepared, is malleable and ductile, like the best platinum obtained by more expensive processes. Its specific gravity is 22.630. On account of its impenetrability to acids in general, platinum vessels are used in the manufacture of sulphuric acid; also for many purposes in the chemical Laboratory. From its great infusibility, it is used in making the touch holes and flash pans of fire arms.

It is presumed that the foregoing experiments will sufficiently exemplify the mode of reducing metals from their ores and other combinations. Further experiments on this subject would be superfluous. A list of the metals with the degrees at which they melt, will be found in the Chapter *On the Expansion of Bodies by Heat.*

CHARACTERISTIC PROPERTIES OF SELENIUM.

A new substance has been discovered by M. Berzelius, which has the properties of a metal, combined with those of sulphur, to so great a degree, that it might be supposed to be a new species of sulphur. In its reguline state, it has a brilliant metallic lustre on the external surface, with a tinge of red: the fracture is vitreous like that of sulphur, but with a very brilliant lustre, of a grey colour. At the temperature of boiling water it is softened, and at a higher temperature it melts: it may be distilled at a temperature approaching to that of boiling mercury. Its gas, with which the heated part of the vessel may be filled, is yellow, exactly like that of sulphur. If it be sublimed in a large vessel, it is deposited in the form of flowers, of the colour of cinnabar, which are not, however, in the state of an oxide. During its cooling, it preserves for some time a certain degree of fluidity, so that it may be moulded between the fingers, and be drawn into threads. The threads, when drawn out to a great degree of fineness, if held between the eye and the light, are transparent, and of a ruby colour; while, by reflected light, they exhibit a brilliant metallic lustre. Its analogy to tellurium has induced him to give it the name of SELENIUM.

It combines with metals, and generally produces a reddish flame. The alloys have commonly a grey colour, and a metallic lustre. The selenuret of potassium dissolves in water without evolving any gas, and produces a fluid of a red colour, which has the taste of hydrosulphuret of potass. If diluted muriatic acid be poured upon the selenuret of potassium, a selenuretted hydrogen gas is disengaged, which is soluble in water, and precipitates all metallic solutions, even those of zinc and iron. The gas has the odour of sulphuretted hydrogen gas, when it is diluted with air: but, if it be breathed less diluted, it produces a painful sensation in the nose, and a violent inflammation, ending in catarrh, which continues for a considerable length of time.

Selenium combines with the alkalies, both in the humid way and by fusion: these combinations are red. The selenurets of barytes and of lime are also red, but they are insoluble. It also dissolves in melted wax, and in the fat oils: the solutions are red, but have no hepatic odour. There exist also hydroselenurets of the alkalies and of the earths. Selenium may be dissolved in nitric acid by the assistance of heat: the solution, when evaporated and sublimed, yields a mass crystallized in needles, which is a pretty strong acid: it has a pure acid flavour, and forms specific salts with the alkalies, earths, and metallic oxides. The selenic acid is soluble in water and in alcohol: its combinations with potass and ammonia are deliquescent: the latter is decomposed by fire, water is given out, and the selenium is reduced. The selenates of barytes and of lime are soluble in water. The selenic acid, mixed with muriatic acid, is decomposed by zinc, and the selenium is precipitated in the form of a red powder. By sulphuretted hydrogen gas an orange-yellow precipitate is thrown down.

CORSICAURUM.

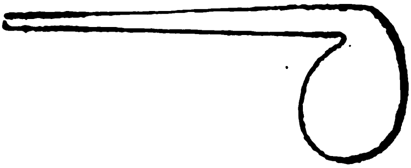
A new mineral earth has been lately found in Corsica, thought to be impregnated with particles of gold. By chemical operation, vases have been made of it, for table services, and it is found to vie in colour and lustre, with the finest vermillion. The name of *Corsicaurum* has been given to it;—it has the property of not discolouring white stuffs, which is not always the case with gold, the most purified and refined.

CXV.

PREPARATION OF CHARCOAL.

Charcoal is usually obtained for chemical purposes, by burning pieces of wood in barrel crucibles. The Charcoal is to be well protected from the action of the air by clay and sand, with which the mouth must be covered. The longer it is kept hot, the better, as a greater proportion of foreign matters will be thus expelled. When made, the Charcoal should be preserved in ground stoppered bottles, to prevent an absorption of air.

To prepare very pure Charcoal, cut a piece of hard oak into slips about half an inch thick, and then into cubes or dice. Put about two or three dozen of these dice into an earthen retort of the annexed figure; and submit them to a strong heat in a furnace. A considerable quantity of volatile matter will come over; and this will be the case until the wood is completely charred. When the volatile matter has ceased to come over, stop up the opening in the retort by a piece of paper, then take off the retort and put it, still stopped up, in a cool place. When cold, withdraw the paper, and let the Charcoal cubes fall into a wide-mouthed bottle which has a glass stopper. Take care when taking any out, not to leave the stopper out for more than two or three seconds.



Observations. The indestructibility of charcoal is well known. Willich says that there still exists charcoal made of corn in the days of Cæsar, which is in so complete a state, that the wheat may be distinguished from the rye. The Bishop of Landaff, in his Chemical Essays, relates that the beams of the theatre at Herculaneum were converted into charcoal by the lava which overflowed that city; and during the lapse of seventeen hundred years the charcoal has remained as entire as if it had been formed but yesterday. The incorruptibility of charcoal was known in the most ancient times; the famous temple at Ephesus was built upon wooden piles, which had been charred on the outside to preserve them; and Dr. Robinson states, that about the middle of the 18th century, a quantity of oaken stakes were found in the bed of the Thames, in the very spot where Tacitus says that the Britons fixed a vast number of such stakes, to prevent the passage of Julius Cæsar and his army. They were *charred* to a considerable depth, retained their form completely, and were firm at the heart.

It appears strange, that two substances so dissimilar as charcoal and the purest diamond, should be in every thing but external appearance, precisely the same. Newton suspected this, and Lavoisier in 1772, proved the combustibility of the diamond. In the Philosophical Transactions for 1797, is related Mr. Smithson Tennant's process for proving the identity of the two substances. He says; " It will appear from the following experiments, that the diamond consists entirely of charcoal, differing from the usual state of that substance only by its crystallized form. From the extreme hardness of the diamond, a stronger degree of heat is required to inflame it, when exposed merely to air, than can easily be applied in close vessels, except by means of a strong burning lens; but with nitre its combustion may be effected in a moderate heat. To expose it to the action of heated nitre free from extraneous matters, a tube of gold was procured, which by having one end closed, might serve the purpose of a retort, a glass tube being adapted to the open end for collecting the gas produced. To be certain that the gold vessel was perfectly closed, and that it did not contain any unperceived impurities which could occasion the production of fixed air, some nitre was heated in it till it had become alkaline, and afterwards dissolved out by water; but the solution was perfectly free from fixed air, as it did not affect the transparency of lime-water. When the diamond was destroyed in the gold vessel by nitre, the substance which remained precipitated lime from lime-water, and with acids afforded nitrous and fixed air; and it appeared solely to consist of nitre partly decomposed, and of aerated alkali.

In order to estimate the quantity of fixed air which might be obtained from a given weight of diamonds, 2½ grs. of small diamonds were weighed with great accuracy, and being put into the tube with ½ oz. of nitre, were kept in a strong red heat for about an hour and a half. The heat being gradually increased, the nitre was in some degree rendered alkaline before the diamond began to be inflamed, by which means almost all the fixed air was retained by the alkali of the nitre. The air which came over was produced by the decomposition of the nitre, and contained so little fixed air as to occasion only a very slight precipitation from lime-water. After the tube had cooled, the alkaline matter contained in it was dissolved in water, and the whole of the diamonds were found to have been destroyed. As an acid would disengage nitrous air from this solution as well as the fixed air, the quantity of the latter could not in that manner be accurately determined.

To obviate this inconvenience, the fixed air was made to unite with calcareous earth, by pouring into the alkaline solution a sufficient quantity of a saturated solution of marble in marine acid. The vessel which contained them being closed, was left undisturbed till the precipitate had fallen to the bottom, the solution having been previously heated that it might subside more perfectly. The clear liquor being found, by means of lime-water, to be quite free from fixed air, was carefully poured off from the calcareous precipitate.* The vessel used on this occasion was a glass globe, having a tube annexed to it, that the quantity of the fixed air might be more accurately measured. After as much quicksilver had been poured into the glass globe containing calcareous precipitate as was necessary to fill it, it was inverted in a vessel of the same fluid. Some marine acid being then made to pass up into it, the fixed air was expelled from the calcareous earth; and in this experiment, (in which 2¼ grs. of diamonds had been employed,) occupied the space of a little more than 10.1 oz. of water. The temperature of the room when the air was measured, was at 55°, and the barometer stood at about 29.8 inches.

From another experiment made in a similar manner with 1 gr. and a half of diamonds, the air obtained occupied the space of 6.18 oz, of water, according to which proportion the bulk of the fixed air from 2 and ¼ gr. would have been equal to 10.3 oz.

The quantity of fixed air thus produced by the diamond, does not differ much from that which, according to M. Lavoisier, might be obtained from an equal weight of charcoal."

In addition, Morveau burnt diamonds in oxygen gas, by means of a lens; and obtained no product of combustion save carbonic acid gas. He also converted soft iron into steel, (carburet of iron,) by cementing it with the diamond. To effect this, he secured a diamond with some filings of iron, in the centre of a piece of soft iron, and putting in an iron stopper. The whole properly enclosed in a crucible was exposed to the heat of a blast furnace, by which the diamond disappeared, and the metal was fused, and converted into a small mass or button of cast steel.

The only perceptible difference between diamond and charcoal, (except those of form, texture, and colour,) is, that the latter contains a small portion of hydrogen: and the great inflammability of charcoal in comparison with diamond, must be owing to its want of compactness.

Fourcroy states that diamonds are usually found in an ochreous yellow earth, under rocks of grit stone; they are likewise found detached in torrents, which have carried them from their beds. They are seldom found above a certain size. The sovereigns of India reserve the largest, in order that the price of this article may not fall. Diamonds have no brilliancy when dug out of the earth, but are covered with an earthy crust.

When washed, they exhibit a sort of phosphoric or vitreous surface, which they preserve until polished. Mr. Mawe found several in the Brazils of various sizes. Some of these, of the size of filberts, may be seen at his repository in the Strand. Though rather opaque, they are of great use in the state of powder for polishing gems.

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* If much water had remained, a considerable portion of the fixed air would have been absorbed by it. But by the same method as that described above, I observed, that as much fixed air might be obtained from a solution of mineral alkali, as by adding an acid to an equal quantity of the same kind of alkali.

CXVI.

To obtain Phosphorus.

Put half a pound of pulverised Phosphoric acid into an earthen retort with the same quantity of Charcoal, previously mixed together: the beak of the retort must be a long one, and is to be immersed in a basin of cold Water. Place the retort in a furnace, gradually heated, by putting in a small portion of fuel at first, and by adding more, until at last a white heat is obtained. Here the Phosphoric Acid will be decomposed, giving out its Oxygen to the Charcoal, which is thus converted into Carbonic Acid Gas: this Gas ascends through the Water, and as it contains minute portions of Phosphorus, (particularly if the distillation be rapid,) combustion will take place as it arises from the surface of the Water. The Phosphorus will come over in a fluid state, and will fall down in congealed drops to the bottom of the basin. When these, and the Gas, cease to come over, separate the apparatus, and examine the neck whether any Phosphorus adheres to its internal surface: this is to be removed by plunging it into hot Water. All the Phosphoric drops may be afterwards brought to unite, by heating them in a vessel of Water. It is then to be preserved in stopped phials containing Water.

Observations. The process recommended by Fourcroy and Vauquelin, is as follows. Take a quantity of burnt bones, and reduce them to powder. Put 100 parts of this powder into a porcelain or stone-ware bason, and dilute it with four times its weight of water. Forty parts of sulphuric acid are then to be added in small portions, taking care to stir the mixture after the addition of each portion. A violent effervescence takes place, and a great quantity of air is disengaged. Let the mixture remain for twenty-four hours, stirring it occasionally, to expose every part of the powder to the action of the acid. The burnt bones consist of the phosphoric acid and lime; but the sulphuric acid has a greater affinity for the lime than the phosphoric acid. The action of the sulphuric acid uniting with the lime, and the separation of the phosphoric acid, occasion the effervescence. The sulphuric acid and the lime combine together, being insoluble, and fall to the bottom.

Now pour the whole mixture on a cloth filter, so that the liquid part, which is to be received in a porcelain vessel, may pass through. A white powder, which is the insoluble sulphate of lime, remains on the filter. After this has been repeatedly washed with water, it may be thrown away; but the water is to be added to that part of the liquid which passed through the filter. Take a solution of acetate of lead in water, and pour it gradually into the liquid in the porcelain bason. A white powder falls to the bottom, and the acetate of lead must be added so long as any precipitation takes place. The whole is again to be poured upon a filter, and the white powder which remains is to be well washed and dried.

The dried powder is then to be mixed with one-sixth of its weight of charcoal powder. Put this mixture into an earthenware retort, and place it in a sand bath, with the beak plunged into a vessel of water. Apply heat, and let it be gradually increased, till the retort becomes red hot. As the heat increases, air-bubbles rush in abundance through the beak of the retort, some of which are inflamed when they come in contact with the air at the surface of the water. A substance at last drops out similar to melted wax, which congeals under the water. This is phosphorus.

To have it quite pure, melt it in warm water, and strain it several times through a piece of shamoy leather under the surface of the water. To mould it into sticks, take a glass funnel with a long tube, which must be stopped with a cork. Fill it with water, and put the phosphorus into it. Immerse the funnel in boiling water, and when the phosphorus is melted, and flows into the tube of the funnel, plunge it into cold water; and when the phosphorus has become solid, remove the cork, and push the phosphorus from the mould with a piece of wood. Thus prepared, it must be preserved in close vessels, containing pure water.

When phosphorus is perfectly pure, it is semi-transparent, and has the consistence of wax. It is so soft, that it may be cut with a knife. Its specific gravity is from 1.77 to 2.03. It has an acrid and disagreeable taste, and a peculiar smell, somewhat resembling garlic.

When a stick of phosphorus is broken, it exhibits some appearance of crystallization. The crystals are needle shaped, or long octahedrous; but to obtain them in their most perfect state, the surface of the phosphorus, just when it becomes solid, should be pierced, that the internal liquid phosphorus may flow out, and leave a cavity for their formation.

When phosphorus is exposed to the light, it becomes of a reddish colour, which appears to be an incipient combustion. It is therefore necessary to preserve it in a dark place. At the temperature of 99° it becomes liquid, and if air be entirely excluded, it evaporates at 219° and boils at 554°. At the temperature of 43° or 44°, it gives out a white smoke, and is luminous in the dark. This is a slow combustion of the phosphorus, which becomes more rapid as the temperature is raised. When phosphorus is heated to the temperature of 148° it takes fire, burns with a bright flame, and gives out a great quantity of white smoke. Phosphorus enters into combination with oxygen, nitrogen, hydrogen, and carbon.

CXVII.

PREPARATION OF BORON.

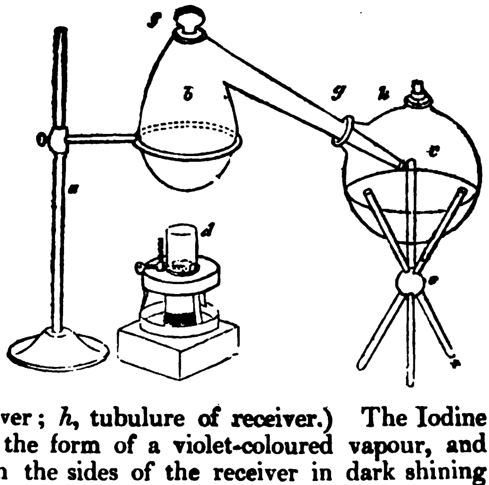
Mix together in a glass-tube, two parts of Potassium and one of Boracic Acid, which has been previously melted and powdered: submit the tube to a gradual heat, until it attains to the temperature of 300° Fahr. when the composition becoming red hot, the combination of the Oxygen of the Boracic Acid with the Potassium will be perfect, and the Boron left free. When the tube is cold, the whole is to be washed out with Water, and placed in a wine-glass or other proper receiver: Muriatic Acid is then to be poured into it, until the newly-formed Potass is saturated. The whole of the liquid is then to be placed upon a muslin filter, on a ribbed funnel. The Salt, (which is a solution of Muriate of Potass,) will filter through, and leave the Boron, which requires to have some more Water passed through it, in order to wash off any remnant of the saline solution. When the Boron is taken off, it may be gradually dried in a watch-glass.

Observation. The solution of muriate of potass is to be kept for evaporation, and the formation of a solid salt, which may be of use in further experiments.

CXVIII.

To procure Iodine.

Digest eight ounces of pulverized Kelp in a quart of Water, and filter it through Paper. Evaporate it by a gentle heat, in a Wedgewood's vessel, the Muriate of Soda will be formed into crystals at the bottom. Mix four ounces of Sulphuric Acid with the uncrystallized solution; and boil it for about five minutes: next put this mixture into a tubulated retort with four ounces of the black Oxide of Manganese, and place the whole over a lamp; let a receiver be attached to it, according to the annexed figure. (*a*, the stand; *b*, retort; *c*, receiver; *d*, lamp; *e*, stand for receiver; *f*, tubulure of retort; *g*, beak of retort where it enters the receiver; *h*, tubulure of receiver.) The Iodine will soon rise in the form of a violet-coloured vapour, and be condensed on the sides of the receiver in dark shining spiculæ, something like Plumbago. Preserve it in a phial, having a ground stopper.



Observations. Iodine was discovered in Paris, by a saltpetre manufacturer, who observed a rapid corrosion of his metal pots in preparing different sorts of sea-weeds, which he used in making carbonate of soda. The following is the improved method of obtaining iodine, as described by M. Van Mons.

"We reduce the rough kelp to powder, and pass it through a hair sieve; when it is not dry enough to be pulverised, we pound it well in a mortar with water and make it boil for half an hour, stirring it continually with an iron spatula; we then filter the mixture, and set it to evaporate, taking care to lift up with a skimmer the salts, a certain quantity of which the hot lye allows to be deposited. If evaporated till crystallization takes place by cooling, the salts become confounded, and a great deal of iodate remains adhering to the crystals.

The crystals, however weak may have been the lye in which they are formed, are always impregnated with iodate, which is in a state of such strong combination, that these crystals, although perfectly dried, redden strongly with sulphuric acid. It is better, therefore, to allow the salt to be deposited in the hot lye, where the muriates are not much more soluble than in the cold one, and where the iodate remains a much longer time in solution. The salt on being separated from the lye, and while it is still hot, should be spread on a hair-sieve, where it may dry itself. When about half of the salt has been dried, it is put aside in order to be afterwards pulverised and washed. The evaporation is continued with the same precaution—that is to say, removing the salt in proportion as the crystals are formed, until it ceases to form any more. The lye is then united with the drain water, and evaporated to dryness. A single lixiviation will then suffice to exhaust the kelp of its salt.

We would advise that this salt should not be thrown away, (as there still adheres to it a great deal of iodate,) until it has been passed through a hot funnel. As the first crystallizations of this salt redden with sulphuric acid as much as the last, they equally contain iodate, which it is necessary to separate. For this purpose the salt is well shaken in large glass funnels; and by little and little, warm water is passed through it, trying at each washing whether the salt continues to redden with sulphuric acid.

The residue of the lye evaporated to dryness gets soon damp in the air. It is necessary, therefore, to preserve it in flasks well corked, if the iodine is not immediately wanted: when the latter is the case, the residue is put into an earthen pan, and pounded continually, incorporating with it by instillation concentrated sulphuric acid;—we say by instillation, for if a drop of acid rests on the place where it falls, a spot of iodine is soon manifested, and a degree of heat developed which it is of importance to avoid.

When enough of acid has been added to decompose the muriate and the iodate, the mixture is transferred to a glass or earthen alembic in order to be distilled. The heat at first being moderate, ought not to be carried to that degree of ebullition that no more muriatic acid is seen to pass, otherwise the iodine, which at that temperature instantly evaporates, may be in part dissolved by that acid.

After iodine has ceased to be disengaged, in order to try if the residue is exhausted, a new quantity of sulphuric acid is poured upon it while it is still hot; if at the moment of contact a white vapour without any tinge of red arises, it is a proof that the iodine is all disengaged. This white vapour is produced by an acid substance, in which we have recognized the following properties:—It does not dissolve iodine; it possesses a flavour similar to that of dilute sulphuric acid; it gives no precipitate with muriate of barytes, but with nitrate of silver and the oxymuriate of mercury it does (the latter precipitate of a pale red colour); and fills the atmosphere with the odour of chlorine.

The soda with which we have experimented was of the species known in commerce under the name of common soda of Fecamp. The pieces recently broken presented in their fracture a bluish gray colour; they were besprinkled with opaque white crystalline knots; the parts which had been exposed to the contact of the air were humid, of a black colour, and contained also knots of salt. Their lye gave about a fourth of their weight in saline products, but no sub-carbonate of soda. The water of a first cold washing contained muriate of lime, and the lye obtained by boiling contained muriate of magnesia. The former muriate was no longer to be found in the lye, having been decomposed by the sulphate of soda. Common soda preserved for thirty years, and which after being damp was completely dried, did not yield less iodine than kelp newly bought.

We made an experiment on the volatility of iodine in air: five grains of crystal were placed in the morning on the reverse of a cup:—towards evening, a great part had been already dissipated; and next morning the whole had disappeared. The temperature of the apartment varied from 8° to 10° R.,* and the odour of chlorine continued for several days.

Two grains of iodine placed in the palm of the hand, dissipated in less than twelve minutes; the spot remained much longer.

CXIX.

To obtain Pure Lime.

Although this substance in its purest state is still an oxide, it may not be improper to rank it, and similar substances, with metals, &c. of whose *simple* nature, chemists are not, in general, without some doubt.—To obtain pure Lime, fill a large crucible half full, with Carbonate of Lime (chalk), and expose it to a very great heat in a clear fire. When the contents of the crucible appear red hot, the calcination is complete. When the crucible is taken from the fire, it is to be covered with a lid to prevent the access of air and Carbonic acid. When sufficiently cold to be handled, put the Lime into well stopped phials for use. That Lime is pure, which does not effervesce when diluted Acids are poured over it.

CXX.

To prepare Alumine.

To a solution of Sulphate of Alumine (Alum) in water, add a solution of pure Soda, as long as a white precipitate falls down. Here the Sulphuric Acid combines with the Soda, leaving the Alumine free. Dry this precipitate quickly, and preserve it in a phial.

Observations. Pure Magnesia, Potass, Soda, Strontia, &c. may all be obtained in a similar way, by precipitating them by another earth or Alkali from their Carbonates; or the Carbonates may be treated in the same way as directed for the Carbonate of Lime, in Experiment 119.

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* About 50° of Fahrenheit.

Pure Potass is obtained from the Carbonate, or what is generally known by the names of Potash and Pearl-ash. It was lately announced in the philosophical journals, that in France, potass has been obtained in great quantities from potatoe stalks, by burning. In order to put this to the test of experiment, Sir John Hay, Bart. and Dr. Mac Culloch made a trial on a large scale, and found that the quantity of potass was so small, that no person could be remunerated by it, for the trouble of the process. Messrs. Taylor of Queensferry, by desire of Sir John Hay, made an experiment on the produce of two acres of potatoe stalks, which yielded 2 casks of ashes, weighing 2 cwt. 23 lb. these produced of soluble substance, only 36lb. containing a great deal of muriate of potass and sulphate of potass. The value of this produce was not more than 2d. per lb. or 6s. in all; and on twelve acres of their own, they had a similar result. Pearl-ash can never be obtained in quantity sufficient to pay for the operation of its extraction, except in countries where the growth of wood is so great as to be an incumbrance. Accordingly, in America, before the land in many places can be cultivated, it is necessary to cut down the forests. The wood is burnt on the spot to save the trouble and expence of moving; consequently the production of potash is a clear gain. No doubt potash might be made with advantage in England by burning *brushwood* and *useless shrubs* in heaps, in a dry state, and lixiviating the ashes.

Pure Soda is obtained from the crystallized carbonate, which is prepared by lixiviating Barilla or kelp, the products of the combustion of Sea weeds. The weeds laid in heaps on the sea shore are dried, and set on fire; after burning for several days, the barilla or kelp is found in pits prepared for its reception. The kelp shores in the Orkney Isles are generally very productive; the whole annual produce is estimated at £80,000, the price being about £18 per ton. It is a singular fact, that the sea weed on the shores of one gentleman's estate, when made into kelp, produces no less than £2000 per annum, while the rest of the property for agricultural purposes, does not produce more than £1000.

Dr. Hermbstead has discovered that potass, lime, barytes, and strontian are not fixed bodies, but are volatalized at various temperatures; and some of them in a small degree even at the common temperature of the atmosphere.

* * *

Lithion.—A new alkali has been discovered in a mineral lately found in the mine of Uten, in Sweden. This mineral consists of 80 parts of silex, 17 of alumine, and 3 of the new alkali. It is said that spodumene contains 8 per cent of it, as does another mineral from Uten, called crystallized lepidolite, which also contains boracic acid, silex and alumine. This alkali is distinguished by Berzelius from the old ones; 1. By the fusibility of its salts; the liquefaction of its sulphate and muriate before they arrive at a red heat, and of the carbonate at the moment when it begins to become red; 2. By its muriate, which is deliquescent, like the muriate of lime; 3. By its carbonate, which does not readily dissolve in water; but to which it communicates precisely the same taste as the other alkalies: the carbonate when raised to a red heat in a platinum crucible, attacks the platinum as if nitrate of soda or potass had been employed; 4. By its great capability of saturating acids, in which it even surpasses magnesia. It has been denominated lithion, to indicate that it has been discovered in the mineral kingdom. Lithion may also be obtained very readily by fusing the mineral with potass, dissolving the whole in muriatic acid, evaporating to dryness, and digesting in alcohol: the muriate of lithion being very soluble in that fluid, is taken up, whilst the other salts remain, and by a second evaporation and solution, may be obtained perfectly pure, or alkalescent. The muriate is itself a very characteristic salt of the alkali. It may easily be decomposed by carbonate of silver, and the carbonate treated with lime yields pure lithion.

Placed in the voltaic circuit, Sir H. Davy shewed that it was decomposed with the same phenomena as the other alkalies. A portion of its carbonate being fused in a platinum capsule, the platinum was rendered positive and on a negative wire being brought to the upper surface, the alkali decomposed with bright scintillations, and the reduced metal being separated, afterwards burnt. The small particles which remained a few moments before they were reconverted into alkali and allowed a short examination, were of a white colour, and very similar to sodium. A globule of quicksilver made negative, and brought into contact with the alkaline salt, soon became an amalgam of lithion, and had gained the power of acting on water, and evolving hydrogen. An alkaline solution was the result.

Since the discovery of the above mentioned alkali, chemists have been assiduously engaged in examining other substances, particularly vegetable ones. The following analytical and characteristic particulars demand our attention.

Cantharidin.—A peculiar substance called *Cantharidin* was found by Robiquet in the *Meloë vesicatorius*, and is supposed to be the peculiar matter which produces vesication. The power of blistering is known to belong in an eminent degree to the *Lytta vittata*, or potato fly, so common in North America; and some American physicians suppose that its vesicatory powers are even greater than those of the Spanish fly. In order to ascertain if this fly contained cantharidin, Dr. Dana digested 110 grains of the potato fly for several days, and, after a series of operations, he obtained a number of minute crystalline plates, which, when washed in alcohol, and dried, were white and pearly. When placed on the tender skin between the fingers, they soon excited itching, and produced redness; but vesication did not take place, from the very minute quantity which was used.

Strychnine.—M. M. Pelletier and Caventou, whilst analysing the vomica nut, and the bean of St. Eustacia, have extracted from these two seeds a substance to which they owe their action on the animal economy. Strychnine is best obtained from St. Ignatius's bean, though it is afforded by some other substances. These seeds are to be reduced to powder by a rasp, and digested in ether; by which a thick, oily substance, of a faint, green colour, is obtained, which is transparent when fluid. The ether being withdrawn, the mass is to be treated with alcohol, until all has been extracted that is soluble in that menstruum; this solution is to be filtered cold, and then evaporated, when it leaves a brownish-yellow bitter substance, soluble in water and in alcohol. Both this substance and the oil, have a very powerful action on animals, similar to that of the bean itself, due to the strychnine contained in them. To obtain the latter substance pure, a strong aqueous solution of the yellow bitter matter is to be treated with a solution of potass; a precipitate falls, which, when washed in cold water, is white, chrystalline, and extremely bitter. If not perfectly pure, it may be rendered so by solution in acetic or muriatic acid, and re-precipitation by potass or magnesia; if the latter is used, the strychnine may be taken up from it by alcohol. Strychnine may be obtained also from the vomica nut, by infusing it in alcohol, and precipitating the clear solution by sub-acetate of lead in excess. Strychnine is soluble in alcohol, but nearly insoluble in water. At the temperature of 50° Fahrenheit, it requires above 6,000 parts for its solution: boiling water dissolves a 2,500th part. Its taste is so powerful, that a solution, containing the six-hundred-thousandth part, possesses it in a very marked degree. It changes to blue, vegetable colours that have been reddened by acids, and forms neutral salts with the acids. It may be obtained crystallized in minute quadrangular prisms, terminated by low quadrangular pyramids, from a solution in alcohol, containing a little water, by allowing it to crystallize spontaneously. It has no smell. It acts violently on the animal system. It is neither fusible nor volatile, but is decomposed at the temperature of boiling oil into products, consisting of oxygen, hydrogen, and carbon.

Elatine.—Dr. Paris has discovered in the plant *Momordica Elaterium* a new vegetable principle, which acts more violently upon the human body than arsenic. It is lodged only in the juice round the seeds, and exists in such a small quantity, that Dr. Clutterbuck obtained only six grains from forty cucumbers; and even of this fecula, although the eighth part of a grain will purge violently, yet not more than one tenth of that quantity of this virulent substance possesses any active virtues. To this active principle he gives the name of *Elatine*. The following, according to Dr. Paris, is the composition of elaterium.

Water	4
Extractive,	26
Fecula,	28
Gluten,	5
Woody matter,	25
Elatine, *Bitter Principle,*	12
	100

The bitter principle in elaterium is very distinct from its extractive matter. The solution of the elatine and bitter principle being diluted, and swallowed, produced only an increase of appetite, while the solution of the extractive matter produced no effect whatever.

Delphine.—Delphine, another of these alkaline salts, was obtained by M. M. Lasseigne and Fenuelle, from the seeds of staves-acre, *Delphinum staphisagria*. The seeds deprived of their husks and rinds, are boiled in a small quantity of distilled water; then pressed in a cloth, and the decoction filtered, and then boiled for a few minutes with pure magnesia; it must now be refiltered, and the residuum left on the filter; when well washed it is boiled with highly rectified alcohol, which dissolves the alkali, and by evaporation, it is obtained as a white pulverulent substance, presenting a few crystalline points. It dissolves in a small quantity in water, but very readily in alcohol. With the acids it forms neutral salts, which are very soluble. Delphine is crystalline whilst wet, but becomes opaque by exposure to air. Its taste is bitter and acrid. When heated it melts; and on cooling, becomes hard and brittle like resin. If heated more highly it blackens, and is decomposed. Water dissolves a very small portion of it. Alcohol and ether dissolve it very readily. The alcoholic solution renders syrup of violets green, and restores the blue tint of litmus, reddened by an acid. It forms neutral salts with the acids, which are very soluble; the alkalies precipitate the delphine in a white gelatinous state, like alumine.

Brucine.—Another alkali has been lately discovered, to which the name of *brucine* has been given, from Mr. Bruce, the Abyssinian traveller having first made known the tree, the false Angustura, or *Brucea antidysentericus;* from the bark of which, the new alkaline substance is obtained. The crystals of brucine, when obtained by slow evaporation, are oblique prisms, the bases of which are parallelograms. When deposited from a saturated solution in boiling water by cooling, it is in bulky plates, somewhat similar to boracic acid in appearance. When in this state, the water may be forced out of it by compression. It is soluble in 500 times its weight of boiling water, and 850 times its weight of cold water. Its taste is exceedingly bitter and acrid, and continues long in the mouth. Given in doses of a few grains, it is poisonous, and acts upon animals in the same way as strychnine. It is not altered by exposure to air; it may be melted by heat at a little above 212°, without decompocition, and thus appears like wax. When exposed to a strong heat it is decomposed. It combines with the acids, and forms neutral and bi-salts. All these salts easily crystallize.

The action of brucine on the animal system is analagous to that of strychnine, but compared with it, its force is not more than as 1 to 12. It induces violent attacks of tetanus; it acts on the nerves without attacking the brain, or injuring the intellectual faculties. It required four grains to kill a rabbit; and a dog having taken three grains, suffered severely but overcame the poison. It is suggested that the alcoholic extract of the Angustura bark may be used with advantage in place of the extract of the vomica nut. It appears that this alkali is combined in the bark with gallic acid; the bark contains, besides, a fatty matter, gum, a yellow colouring matter, sugar in very small quantities, and ligneous fibre.

In addition to the foregoing substances, some others have been discovered, as *Vauqueline* from the *daphne alpine; ambreine* from *ambergrease; and leucine* from *wool,* and particularly from the muscular fibre, (*fibrine,*) which when treated with sulphuric acid, yieldc a particular white substance, which has been called *leucine.* When a solution of leucine, in lukewarm water, is evaporated spontaneously, a number of small isolated crystals are formed at its surface. They are flat, perfectly circular, and have exactly the shape of the moulds of buttons, with a rim round their circumference, and a point of depression in their centre. Leucine has the taste of the juice of meat. It appears to be specifically lighter than water. It melts at a temperature considerably above that of boiling water, and spreads an odour of putrid meat, subliming partly in the form of small white insulated crystals. Leucine dissolves easily in nitric acid, and produces fine colourless and divergent needle crystals, which are a new acid, *analagous* to the *nitro-saccharic.* This *nitro-leucic* acid forms with salefiable bases, salts which have quite a different arrangement from the *nitro-saccharates.* Combined with lime it yields a salt, which crystallises in small rounded groupes, and is unalterble in the air.

CHAPTER IV.

EXPERIMENTS ON THE EXPANSION OF BODIES BY HEAT.

GENERAL OBSERVATIONS.

THE Expansion of Bodies by Heat is that change or extension of bulk which they undergo when submitted to its influence. Whether Caloric, or the principle of Heat, is a peculiar body, has not yet been determined, and probably the existing knowledge of facts is not sufficient for the settlement of this question, we shall for the present, in conformity with the generally received theory, consider Caloric as a subtle body, which, insinuating itself between the particles of other bodies, causes their Expansion, though it may not be improper to state, that it has been maintained that the Phenomena of Heat are caused by motions or vibrations of atoms, which motions are caused by the collision, percussion, or re-action, of aggregates.

CXXI.

LIQUIDS EXPAND WHEN HEATED.

Fill a phial about three-fourths with coloured Water, Ether, or Alcohol, and immerse it in a basin of hot Water:—Expansion will be evident by the rising of either of the liquids in the phial. Ether is the most expansible of these, and Water the least.

Observations. It is upon this principle of expansion by heat, that evaporation depends. Evaporation is the ascension of fluids combined with caloric, into the atmosphere; where, on account of their rarity, or levity, they float, until by some future operation of nature, they are condensed by an abstraction of their heat. When water is left in a basin for a considerable time, it will disappear:—Where did it go?—The heat of the atmosphere combined with it, to form vapour.

CXXII.

FLUIDS DO NOT EXPAND EQUALLY WHEN HEATED.

Pour into three glass tubes with bulbs, as much Alcohol, Water, and Mercury, as will fill the bulbs;—the Water may be coloured blue or black with ink, and the Alcohol red:—immerse these tubes in a tumbler of warm Water, and note how much each fluid has risen. The Alcohol will be found to have risen highest, the Water next, and the Mercury least.

Observations. The rising of the fluids in the tubes, is owing to their specific capability of expansion, for each has received an equal quantity of heat: the mercury being least expansible, does not, of course, rise so high as either of the others. It is upon this principle that the art of making thermometers is founded.

CXXIII.

AIR EXPANDS WHEN HEATED.

Half fill a bladder with Air, and hold it near the fire, with its neck tied so tight, that none can escape or enter; the bladder will begin to swell, and will soon be completely distended. This Expansion can only be owing to the combination of Caloric with the Air.

Observations. Upon the principle of the expansibility of air, was invented the Air Thermometer, which is a very delicate test for the smallest portion of caloric, or excitement of atomic motion. It consists of a glass tube with two legs, supported on a sliding stand. In this tube there is a red liquid, (sulphuric acid coloured by carmine) which rests at the bottom, and a little way up in each leg. When used, the rays of heat rarify the air in one of the legs, which causing an increase of bulk, the liquid is propelled upwards into the other leg, to a certain distance; this is correctly ascertained by a graduated scale: for by the height to which the liquid is propelled, the quantity of heat proceeding from bodies, is ascertained. These instruments are so exact, as to be used in denoting temperatures, which could not be ascertained by other thermometers.

CXXIV.

WATER EVAPORATES FROM THE SURFACE OF THE EARTH.

Procure a bell-glass, whose edge is turned up in the inside, so as to form a groove, or channel: place it on a smooth garden-walk, and lute it to the grass, by throwing a little dry sand round the edges. Leave it in this state for a few days; at the end of that time, if it is examined, the groove will be found to contain a small portion of Water. This is caused by an Evaporation of the Water from the Earth;

but the vapour being obstructed and cooled in its ascent, by the sides of the glass; is condensed, and runs down in small streams, towards the groove below. This experiment is more striking, if performed in that season of the year when the Earth is so dry, and the Grass so withered by the heat of the Sun, as to seem unable to afford the least particle of moisture.

The two following experiments present further proofs of the existence of water in a state of vapour in the atmosphere.

CXXV.

POTASS BECOMES MOIST

When exposed to the Atmosphere.

Place a piece of pure Potass in a saucer, and leave it exposed to the air. In a few minutes it will crack and fall to powder; in a short time the whole will become quite moist, and will at last be dissolved.

CXXVI.

SULPHURIC ACID BECOMES ENLARGED IN BULK

When exposed to the Air.

Expose some Sulphuric Acid, in a *graduated glass*, to the air for a few weeks. At the end of that time, from the tendency which this fluid has to combine with Water, it will be found, that the bulk is enlarged by an absorption of watery vapour from the surrounding atmosphere. It will also be found, that the specific gravity of the Acid is not so great as it was previously. In fact, it will now be diluted Sulphuric Acid. In these experiments, it will readily be perceived, that the Water, which dissolved one substance and diluted the other, existed previously in the air, in the state of elastic vapour.

Observations. Evaporation depends much upon the surface of land or water exposed to the atmosphere.:—From seas and rivers it is very great. They send up as much vapour, as is equal to their supply of water from streams and rain; and the balance is kept up by future condensation. Dr. Halley, found that the quantity of water evaporated from the Mediterranean Sea, in a summer day, amounts to 5,280 millions of tons! Mr. Dalton found that the evaporation from water in a flat vessel, exposed to the Sun, was about 0.2 of an inch, in an intensely hot summer day. By the following Table, it will be seen, that the *mean* evaporation from the surface of water throughout the year, is 36.78 inches. The proportions for each month are as follow:

	Inches.		Inches.		Inches.
January, .	1.50	May, . .	4.34	September, .	3.18
February, .	1.77	June, . .	4.41	October, . .	2.51
March, . .	2.64	July, . .	5.11	November .	1.51
April, . .	3.30	August, .	5.01	December .	1.49

Bishop Watson asserted, that even in the heat of summer, when there is no rain, and the ground is dried up, no less than 1,600 gallons of water are evaporated from a single acre in one day. What must be the quantity of water evaporated from the surface of the whole earth and seas in this time! And what must the bulk of that vapour be, when each gallon of water is expanded to 1,400 times its original bulk! It may be asked, what is the use of this immense evaporation? Where does the vapour go to? And does not the earth feel the loss of so great a quantity of that moisture, which renders it fertile? To this it is answered, that, for a short time, the vapour is sustained in the form of clouds; that these clouds are condensed in due time by electricity; that this condensation is in the shape of mist, dew, rain, snow, and hail, which falling on the earth, fertilize all parts of it; and that, were it not for this mode of condensation, the inlands of all countries would be deprived of moisture, and rendered complete desarts, unfit for the nourishment of animals or vegetables.

Evaporation is much increased when the temperature of fluids is raised by natural or artificial means.—Liquids will sooner be converted into vapour in the heat of summer, or in warm climates, than in winter, or in cold ones. When heat is applied to liquids, a very quick evaporation takes place. This cannot be better exemplified, than when water in a saucepan or teakettle emits vapour from combination with the heat of a fire.

All salts are separated from their solutions by evaporation; for the water rises in vapour, and leaves the solid particles to crystallize. This may be proved by dissolving any salt in water, and then placing the vessel containing it, close by the fire;—when the water disappears, crystals will be formed. In the large way, saline solutions are first *boiled*, to rid them of the main body of water, (which being formed into vapour, speedily flies off;) and having thus attained a certain consistency, or having become *thicker*, they are poured into shallow vats; a more moderate heat is now applied, by which a slow evaporation is kept up, so as to prevent disturbance of the crystallization; and in due time the desired effect is produced. In this way, muriate of soda, (sea salt,) carbonates of soda, and potass, sulphate of magnesia, sugar, &c. &c. are obtained. The late Mr. Thompson has applied steam to the evaporation of solutions of sulphate of potass, &c. found at Cheltenham. A chamber, containing a dozen of vats, is heated by pipes proceeding from a steam-boiler; thus the evaporation is performed with little trouble or expence.

In warm countries, large pools are filled with sea and other saline waters, from which the solar heat causes quick evaporation, leaving the salt behind. This art is known to the South Sea Islanders. In the Bay of Biscay, bay-salt is made in the same way. The Egyptian lakes where soda is obtained, are filled by the overflowing of the Nile, and afterwards dried up by the heat of the sun, the salt is accordingly left behind. Borate of soda is obtained from the waters of a lake in Thibet, by the same process. The solution is poured into shallow cavities made in the earth, and evaporated by the heat of the sun. In this country too, sea-water is first evaporated in pits, before it is submitted to ebullition. All saline solutions are thus *concentrated*, and, of course, do not require so much expence of fuel.

CXXVII.

LIQUIDS WHOSE BOILING POINTS ARE LOW,

Lose most by evaporation.

Pour equal quantities of Ether, Water and Sulphuric Acid into tea cups, and place them in a room of moderate temperature. In a quarter of an hour, the Ether (if not more than 2 drams) will totally disappear:—the water will require a longer time to dry up; but the Acid will remain undiminished for any length of time.

Observation. This experiment may be varied, by mixing in a wine glass, some spirits and water; and in another, some water and sulphuric acid: expose these to a moderate heat. It will be found, that, from the first the spirits have evaporated and left the water tasteless; whilst from the latter, the water will have evaporated, leaving the acid stronger or more concentrated than when in the diluted state.

CXXVIII.

THE EVAPORATION OF ETHER ABSTRACTS HEAT

So rapidly as to freeze Water.

When fluids evaporate rapidly, they themselves, or contiguous fluid bodies, will be frozen, by the abstraction of that heat which is required to convert them into Vapour Wrap a linen rag round a phial containing Water, and moisten it frequently with Sulphuric Ether; when this has been repeated several times, without interruption, the Water will be frozen.

CXXIX.

WATER MAY BE FROZEN BY THE EVAPORATION OF

Sulphuret of Carbon.

This substance evaporates very rapidly, and possesses extraordinary cooling powers. Wrap round a phial half filled with Water, a piece of linen-rag, moistened in Sulphuret of Carbon, which is the most volatile substance known and which will evaporate so quickly, that the Water will speedily be frozen. The volatility of this liquid is so great, as to abstract almost instantaneously, a great quantity of heat from the Water.

CXXX.

SULPHURIC ACID MAY BE FROZEN BY THE EVAPORATION *Of Sulphuret of Carbon.*

Half fill a phial with Sulphuric Acid, and surround i with a rag moistened by Sulphuret of Carbon. The Aci will speedily be frozen.

CXXXI.

FLUIDS EXPAND GREATLY WHEN ATMOSPHERIC *Pressure is removed.*

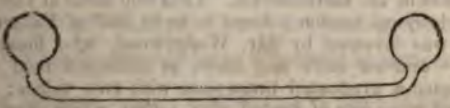
Place a bladder half-filled with Air, (the neck of which is well secured,) under the receiver of an Air-pump. As the Air is exhausted from the receiver, the bladder will become distended. This is caused by the removal of the Air which was external to the bladder, and the consequent expansion of that within. As soon as the bladder is take from under the receiver, it will collapse by the pressure o the surrounding atmosphere.

Observations. Atmospheric air, which presses equally on all bodies considerably prevents their expansion. This is very evident in the cas of gases, for the instant that this pressure is removed they becom more rare: also in fluids, for they are capable of assuming the gaseou form, by uniting with only a small portion of heat.

CXXXII.

If the instrument, called the Pulse-glass, be held in an *inclined* position, in the palm of the hand; the fluid in the bulb will be in a state of ebullition, and will send its vapour up towards the other end. This vapour will be immediately condensed, from the abstraction of its Caloric by the thin glass and other surrounding objects; it will then run back in a fluid state to the bulb at the bottom and will be again sent forth in vapour, as before.

The Pulse Glass (of which the following is a figure,) is a tube having a bulb at each end; and, like Spirit Thermometers, is filled with coloured Alcohol.

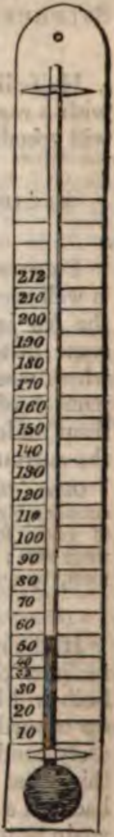


Observations. It is upon the principle of expansion, that thermometers are constructed. Indeed in such cases, expansion and evaporatio are synonimous; for if the fluids in these instruments were not confine by the glass they would speedily disappear.

General observations on the construction and use of Thermometers, &c.

The thermometer is an instrument, which, having some liquid in a glass tube, (such as mercury, linseed-oil, or alcohol,) indicates, by the expansion or ascension of that liquid, what degree of heat exists in any body to which it may be applied. Those with ivory scales denoting the degrees of heat, are the best calculated for ordinary purposes, such as to ascertain the temperature of the air;—those which are naked, having the scale graduated *on the tube*, are fitted for ascertaining the temperature of sulphuric acid and other corrosive fluids.

The manner in which thermometers are made, is by pouring mercury, alcohol, &c. into glass tubes, of certain diameters, having bulbs at the bottoms. The bulb is to be held over a lamp until the liquid boils;---the ebullition expels the common air from the tube, which is to be sealed at the upper-end, by the flame of a lamp and blowpipe: and a vacuum is thus formed above the liquid, which is evident from its cooling, and falling down towards the bulb. When heat is afterwards applied, (as there is no interruption by atmospheric pressure,) the liquid ascends, and denotes the degree of heat received, by appearing on a level with any particular degree of the scale attached. The degrees are marked by tens, thus, 140, 150, 160, &c.; and when reference is made to them in books, the word *degree* is left out, and the sign ° is substituted, thus, 140°, 150°, 160°. In Fahrenheit's thermometer, (see the annexed figure,) zero, or 0°, is that point which indicates the cold produced by a mixture of snow and muriate of soda,—the freezing point of water is 32°, and the boiling point 212°. When any temperature below zero, or 0°, is mentioned in writing, the sign —, or *minus*, is always prefixed, as—38°, meaning 38 degrees below that point where cold is produced by a mixture of snow and muriate of soda. Alcohol thermometers are used, to indicate degrees of temperature as low as 110 below zero,—when it is said to freeze:—whereas a mercurial thermometer cannot indicate a lower temperature than 39 below zero, which is its freezing point. An absolute deprivation of caloric is supposed to be several thousand degrees below zero.



Wedgewood's pyrometer, constructed to measure the heat produced by furnaces, has its zero, or lowest point, at 1077° of Fahrenheit's thermometer, and every succeeding degree of the pyrometer is equal to 130 degrees of the thermometer. Thus iron melts at 158° of Wedgewood, which by calculation is found to be 21,637° of Fahrenheit. The pyrometer was invented by Mr. Wedgewood, who found that clay continues to *contract* more and more, as additional heat is applied. He constructed a graduated brass plate with two ridges; into which were inserted small bits of heated clay,---that which was most contracted by the heat of the furnace where it was used, entered furthest between the ridges, and denoted the highest temperature,---the highest ever known by this method, was 185°, which is equal to 25,200 of Fahrenheit.

Besides these, there are other thermometers; namely, Reaumur's, which was formerly used in France: the centigrade, which is at present in use there: and De Lisle's, which is used in Russia: but a description of all which, in this place, would be of little utility. A very delicate thermometer on the plan of the differential one, but upon a different principle as to the fluid employed, has lately been invented by Dr. Howard. In Leslie's differential thermometer the degree of heat is measured by the expansion of air; Dr. Howard's by the increase of the expansive force of the vapour of ether or spirits of wine in vacuo. It is a test of great delicacy, and is easily constructed. A glass tube being first made with a bulb at each extremity, in one of which is left a small orifice, a portion of ether or spirit of wine is then introduced, and heat being applied, is brought to a state of active ebullition. At this moment the orifice is closed with a piece of wax, and, hermetrically sealed by the blow-pipe. The tube may then be carefully bent in form of a hook, and the scale and foot being adapted, the instrument is finished. This thermometer is more delicate than Mr. Leslie's. When a heated body, as the hand, is brought near to one of the balls, the liquor sensibly ascends or descends; and as soon as the cause is removed it begins instantly to return to its former level. If the two balls were entirely freed from air, the liquor would always remain at the same level in each branch of the tube, except a trifling difference caused by capillary attraction. This perfection cannot be attained by the most skilful artist; there always remaining behind, notwithstanding all care to prevent it, a small residuum of air which is sufficient to make a difference in the height of the two columns. To obviate this, before the scale is adapted the liquid is all to be brought into one ball, and the instrument is then reversed and left for a considerable time in that position, that both balls may acquire an equal temperature, and that the portion of air may be equally diffused through them. It is then to be restored to its proper position, and the point at which the liquid finally settles is to be marked at the commencement of the scale. The same operation is to be repeated whenever the instrument has been deranged by transportation or other cause. The best mode of constructing this thermometer, is to bend the tube previous to the introduction of the ether, a considerable portion of which should be boiled out of the tube in order to insure the expulsion of the atmospheric air; it is also convenient to tinge the ether of a red colour by the addition of tincture of cochineal.

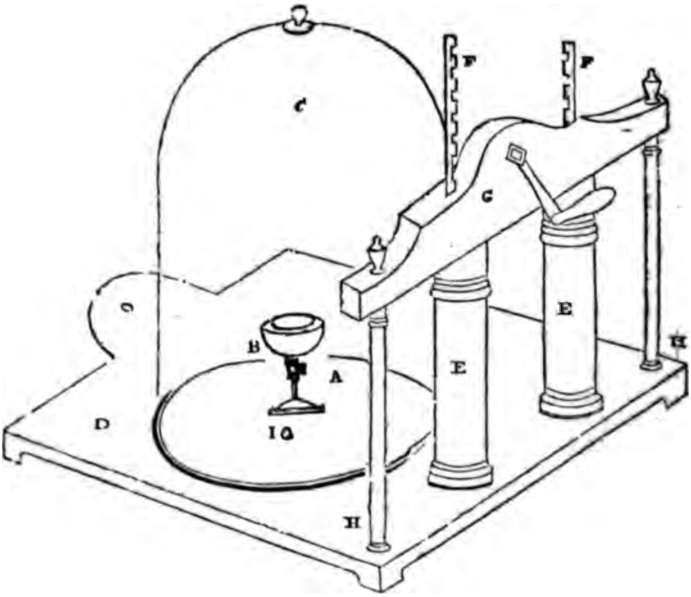
Mr. Brande has constructed upon the same principle, a photometer and an ethrioscope, both of which, though liable to some objections, are most curiously sensible to the impression of light, and to the frigorific emanations of the heavens.

CXXXIII.

EXTENSIVE EVAPORATION TAKES PLACE UNDER AN AIR *Pump when Atmospheric Pressure is removed.*

If into a shallow vessel, containing Water, another a little smaller be put, containing Sulphuric Ether; and both be placed on a stand under the receiver of an Air-pump: —when the Air is forced out, the Ether will boil, whilst the Water freezes.

Observation. The following figure of an Air-pump, with vessels upon the stand, will illustrate the mode of performing this Experiment.



A, Is a small stand, supporting the substances under experiment; B, a glass vessel containing Water, and a smaller one inside, which contains Ether; C, the bell-glass receiver; D, the platform; E, E, brass cylinders for working the pistons; F, F, the pistons; G, the handle for working the pistons up and down, in order to extract the Air; H, H, supporters of the pump, and I, the hole in the centre of the platform, for allowing the air to pass out, when the pump is in motion.

CXXXIV.

If 1 drachm of Water be put into a watch-glass, placed under the receiver, and another watch-glass be placed gently in it, so as to form a layer of Water between them; and if a dram of Ether be poured into the upper watch-glass, the above-mentioned effect will more readily be produced. The Ether will disappear whilst the Water is converted into Ice; which will cause the two glasses to adhere.

Observation. In these two experiments, the pressure of the atmosphere being removed, the ether readily assumes the gaseous form; and, in so doing, robs the water of so considerable a quantity of caloric, that ebullition and excessive cold take place in two fluids at one time, and in the same place.

CXXXV.

WATER MAY BE FROZEN BY A RAPID EVAPORATION FROM *its surface.*

Place under the receiver of an Air-pump, a flat circular glass vessel, twice as large as a tea-saucer: fill it half way up with concentrated Sulphuric Acid, and place in it a glass stand, or ring, supported by three glass legs. Place a very small shallow Evaporating-dish, nearly filled with Water, upon this stand, and rapidly exhaust the receiver of its Air. As the Air is rarefied, the Evaporation of the Water will be proportionally quick. This vapour would fill the receiver, and prevent any further Evaporation, did not the extensive surface of Sulphuric Acid at the bottom of the receiver absorb it as rapidly as it is formed. The vapour which arises from the surface of the Water robs the whole quantity of a great portion of heat; consequently the Water will be frozen. This phenomenon will begin to take place soon after the exhaustion is commenced. If the cock be now turned for the admission of the air, the receiver may be removed, and the cake of Ice taken from the upper vessel.

Observations. The absorption of Water, even from the atmosphere, is a well-known property of Sulphuric Acid, consequently, it is well adapted for this purpose in vacuo. In this experiment the absorption is very rapid, consequently Caloric must be evolved, as is usual in the combination of Sulphuric Acid and Water; therefore, the diluted Acid will be hot, whilst the Water is frozen.

Professor Leslie has discovered that the dried powder of *porphyritic trap* is a more powerful and permanent absorbent than even Sulphuric Acid; for, in an exhausted receiver, Water is congealed by it, more quickly than by any other substance.—It absorbs one fifth of its own weight of Water. He thinks, that two quarts of it, spread on a large dish, would in a few minutes freeze, in an exhausted receiver, 8 or 12 ounces of Water, in a cup of porous earthenware. After each process, its power may be restored, by drying it before a fire, or by the heat of the Sun: consequently, *by this method, Ice may always be procured in hot climates.* The same experiment has frequently been tried with *Oatmeal,* and with the same results. *Pulverized Pipe-clay* also acts in the same manner.

CXXXVI.

THE EVAPORATION OF SULPHURET OF CARBON, UNDER *the Receiver of an Air-pump, will almost freeze Alcohol.*

Wrap round a Spirit Thermometer, a piece of rag, moistened by Sulphuret of Carbon. If the Thermometer previously indicated the ordinary heat of the atmosphere, the fluid will speedily fall to Zero; and if placed under the receiver of an Air-pump it will sink to—80°.

General Observations on Evaporation. In lowering the temperature of bodies, Evaporation is of extensive use.

Wines may be cooled, by wrapping the bottles round with wet cloths. Wine-coolers act upon the same principle; for the vessels into which the bottles are put, are made of a spongy or porous ware, through which the water exudes. This water evaporates, and in doing so, robs the wine of its heat.

Wet cloths are used in Asiatic countries, to cover the windows; by which means the apartments in the houses are kept cool. A similar precaution is taken in Sicily and Malta, during the period of the *Sirocco*, or hot wind. Evaporation, by sprinkling the floors with perfumed waters, is a luxury much used by Eastern monarchs. After Rain, the weather is cold, in consequence of an immediate and extensive evaporation.

A most cruel kind of punishment is practised in one of the Asiatic countries. The head of the criminal is shaved, and he is placed in such a situation that drops of water continue descending upon one part of his head, by capillary attraction, from a vessel above. The drops evaporate, and consequently carry away as much heat as gives to them the elastic form; and as one does not descend until the other is dried up, the continual abstraction of heat is the cause of extreme agony. The unfortunate victim dies raving mad.

GENERAL OBSERVATIONS ON EBULLITION.

Ebullition is that salient motion which fluids exhibit, when strongly heated.

Boiling is the term generally applied to this motion, when it takes place under the common pressure of the atmosphere. When solid bodies are heated, they attain high temperatures, without the escape of any of their particles: this is not the case with fluids; for, having arrived at certain heats, they are rapidly formed into vapour, or steam; which, overcoming the pressure of the air, ascends, and robs the fluid of a portion of heat sufficient to preserve itself in the elastic form.

The process of boiling may easily be exemplified, by half-filling a Florence-flask with water, and suspending it over a lamp. Bubbles of atmospheric air, with which the water was previously impregnated, will first appear at the bottom of the flask, and, from their levity, arise to the surface, where they will be discharged into the atmosphere. As the heat is encreased, *bubbles of vapour* are formed; these also rise to the surface: they will do so more frequently, and with increased agitation and violence, as the process goes on.

By these means, the fluid under operation cannot attain a higher temperature than that in which ebullition is exhibited; for, although the boiling water is equally heated, at one instant of time, still an immediate addition of heat forms the lower stratum into elastic vapour, which, from its levity, rises to the surface, as a bubble, and there explodes, carrying off with it the superabundant portion of heat which it had just received.

Hence, it is useless expence and labour to add fuel to a fire on which a liquid already boils, in order to make it boil faster, or to bring it to a higher temperature. For as long as there is no extraordinary pressure, the fluid cannot become hotter than its boiling point permits: for example, the hottest fire cannot render water, in an open vessel, hotter than 212°; the attempt to give it a further heat would prove abortive, for it could only serve to dissipate the water in the form of steam.

Ebullition, therefore, properly speaking, is the motion of fluids when they evaporate rapidly by being submitted to heat.

It happens, however, that all fluids do not boil at the same heat; as may be known by immersing a Thermometer in them at the time: six ounces of ether would be completely evaporated, or boiled away, if placed over a fire, before two ounces of water could enter into a state of ebullition: and six ounces of water would disappear in the same manner, before two ounces of linseed oil could be made to boil. The following table shews the boiling points, or temperatures, of various liquids:—

Of Fahrenheit's thermometer.

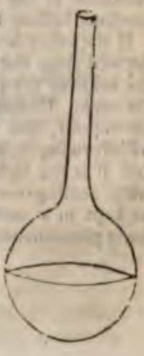
Sulphuric Ether	boils at	98°	Phosphorus	———	554°
Liquid Ammonia	———	140°	Oil of Turpentine	———	560°
Alcohol	———	176°	Sulphur	———	570°
Water	———	212°	Linseed Oil	———	600°
Nitric Acid	———	248°	Mercury	———	660°
Sulphuric Acid	———	540°			

Boiling is so common an operation, that it is almost needless to describe its use. It is well known, that water in its cold state has not the power of solution or digestion that boiling water has. By means of boiling water, animal and vegetable substances are in part dissolved, before they enter the stomach to be further digested. Another important use of boiling, is the purification of water from earthy salts. The Thames and New River Waters always deposit a crust on the inside of tea-kettles and steam-engine boilers; consequently the water boiled in them is purified. In rainy weather, so much earth is washed into rivers, that it is absolutely necessary to boil the water, before it is drank. In China and Holland, in consequence of the passage of the rivers over a clayey soil, the inhabitants are accustomed to purify all the water they use, by boiling. When water is boiled, it is insipid for a considerable time, from the loss of atmospheric air, with which it had previously been combined; but if permitted to stand in an open vessel, it will soon again be impregnated by it, and recover its ordinary taste.

Fluids boil at different temperatures, according as they are affected by pressure of the atmosphere, or of any other body: and less or more heat is required for their ebullition, according as the body which presses on them, is light or heavy.

CXXXVII.

FLUIDS BOIL AT A LOW TEMPERATURE, *When Atmospheric pressure is removed.*



Pour some water into a a Mattrass, (see the annexed figure,) and set it over a lamp: when in the act of boiling, put in a tight cork, and take it off the stand at the same instant: the Ebullition will cease; but will recommence as soon as the cork is withdrawn.

Repeat the experiment; and paste a piece of bladder over the cork as quickly as possible, in order to prevent the access of Air. The part of the flask unoccupied by the Water, will be occupied by Steam: but if a piece of calico dipped in cold Water, be wrapped round the upper part of the flask, the Steam will be condensed, and a vacuum being now formed, the Water, without the assistance of any more heat, will boil a second time. Preserve the flask corked as it is, it will boil at any time, by an heat of 88°.

Observation. The phenomenon of boiling when the liquid is actually cooled, is owing to the remova! of an atmosphere of steam from its surface, by condensation. The warm liquid having room for evaporation or ebullition, enters into that state with rapidity.

CXXXVIII.

WATER BOILS AT 88° FAHRENHEIT,

When Atmospheric Pressure is removed.

If any quantity of boiling Water, in a vessel, be cooled down 124 degrees, that is, to 88°, and put under the receiver of an Air Pump, it will boil at that temperature.

CXXXIX.

ETHER BOILS AT A LOW TEMPERATURE,

When Atmospheric Pressure is removed.

Let a small quantity of Sulphuric Ether be made to boil at 96° in a phial. Whilst in the act of sending up much vapour, let a tight cork be fitted into it, (as it is withdrawn from the fire,) and a piece of wetted bladder laid over the cork: the air being expelled by the Ethereal Vapour, there will remain a vacuum above the liquid, when the phial is made cold. In this state, the least addition of heat, from the warmth of the hand, the flame of a candle, heat of the Fire, or Water moderately warm, will make it boil.

Observations. This is a delicate experiment, and requires a complete exclusion of the air. When this is completely expelled, the ether will continue boiling for any length of time, in a warm room.

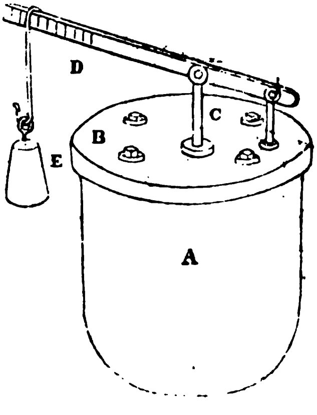
If the ether is submitted (in a warm room) to any heat above that derived from the hand, the vapour must be condensed as it approaches the neck of the phial, by wrapping a small strip of wetted linen round the neck. Unless this be done, a very few degrees of heat will so expand the vapour, that the phial will burst. If the cork be put in, in the act of withdrawing it from the fire, (at the commencement of the experiment,) and if it fits tight; also, if (in addition to the bladder,) it be covered with sealing-wax so as effectually to exclude the air; the phial may be kept in a cool place, for constant use, and will always exhibit the same phenomenon.

CXL.

MECHANICAL PRESSURE RETARDS EBULLITION.

If water, in an open vessel, be submitted to the heat of the strongest fire,—even that required for the liquefaction of iron;—the Thermometer will not indicate any more heat in it, than will raise the Mercury to 212°. But if an equal quantity of Water, in a Papin's digester, be put on even a moderate fire, the temperature will rise to 400°; but still the Water will not boil.

Observation. It is evident, that, in the first case, excess of temperature in the water is prevented by an union of the superabundant portion of caloric with part of the water, which is converted into steam: and in the second case, that the steam is so forcibly restrained from escape that the caloric combines with the whole mass of water, and raises the temperature to 400°.



Papin's digester, which the annexed cut represents, was constructed on the principle of mechanical pressure being necessary, to elevate fluids to higher temperatures than their common boiling points.

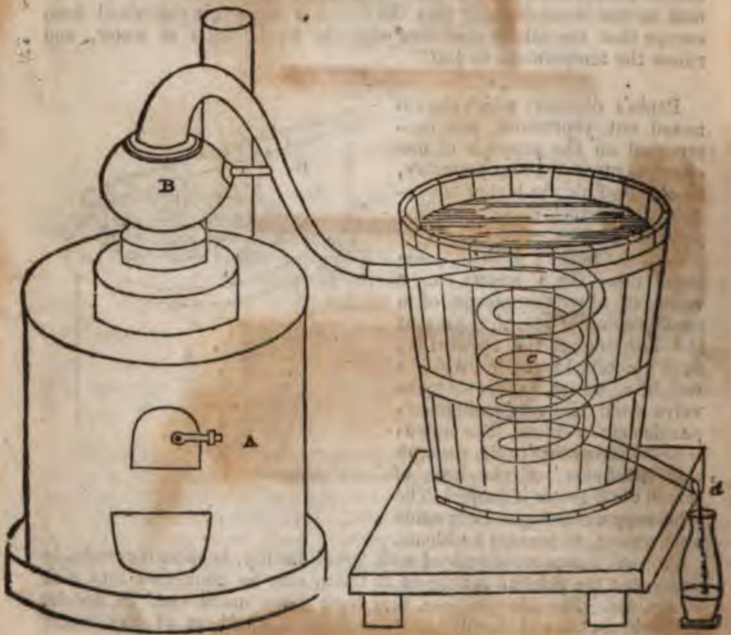
A, is the boiler; B, the lid, fastened down by 4 screws; C, a valve to allow the escape of a small portion of steam, to prevent the bursting of the apparatus; D, is a notched lever, on which a weight E, hangs, to prevent the valve from rising by a slight expansion of the steam. The weight is heavy, according to the strength and thickness of the iron, of which the digester is formed. The whole apparatus is generally made very strong, to prevent accidents.

Animal bones are dissolved with great facility, in these digesters, in order that the gelatine contained in them, may be converted into rich soups, &c. For this purpose, they have been much used in hotels, coffee-houses, and family establishments. The heat of the water contained in this apparatus, is so intense as to melt lead.

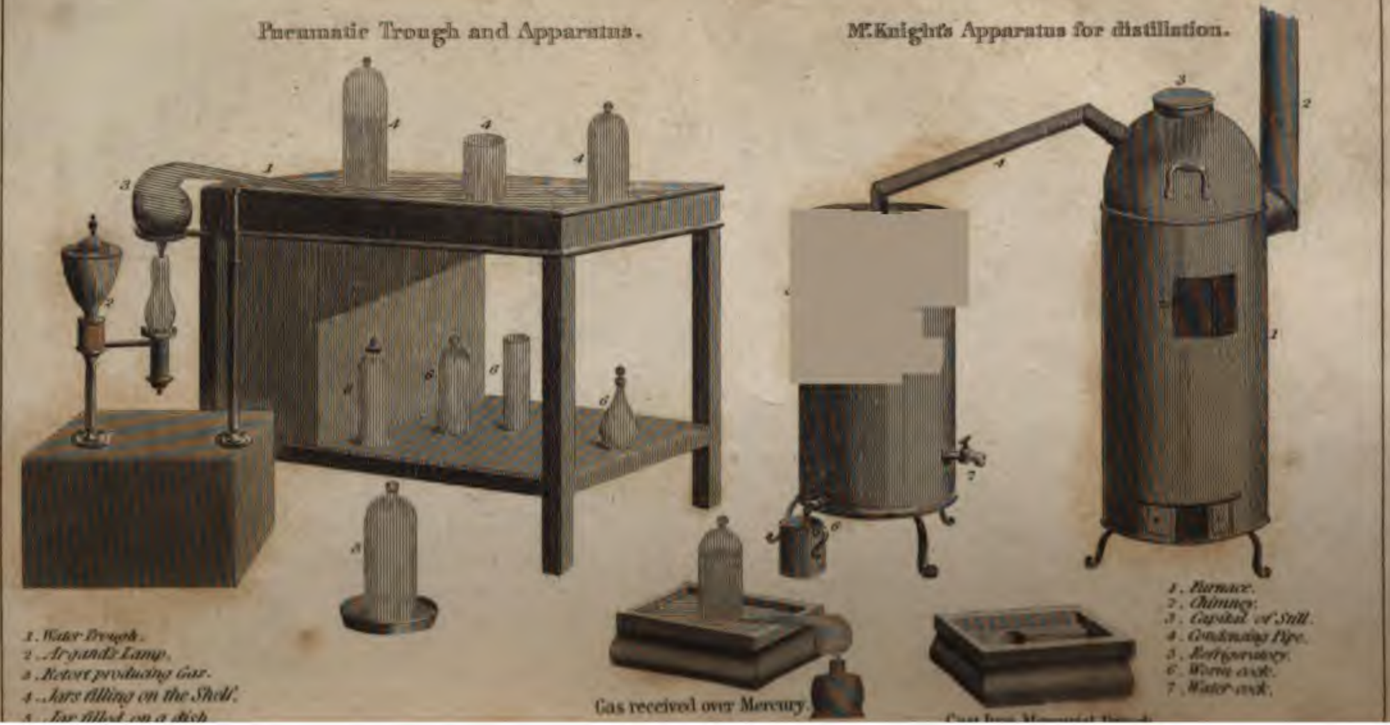
General Observations on Distillation.

Distillation is that process, by which the volatile particles of boiling fluids are vaporised, condensed, and collected in appropriate vessels.

It is performed by submitting liquids to heat, in close metallic or glass vessels. The more volatile particles being in a state of vapour, ascend in the body of the still, or lower vessel, in which the liquid boils, and enter the head or capital. From thence the vapour passes into a metallic tube, called the worm, or condensing tube, which is cooled externally, by means of water contained in a large tub or wooden vessel, termed the Refrigeratory. The vapour is thus condensed, (or reduced to a liquid state,) by parting with its heat through the metal to the surrounding cold water, and descends through the worm into any convenient vessel placed below. This latter part of the apparatus is named the Receiver. The following engraving represents the apparatus by which the process of distillation is usually carried on.



A, Is the furnace on which the Still is placed; B, the head, or capital; c, the refrigeratory, containing the worm; and *d*, the vessel for receiving the distilled product. Mr. Knight's apparatus for distillation may be seen in Plate 2.



Pneumatic Trough and Apparatus.

1 . Water Trough.
2 .. Argand's Lamp.
3 .. Retort producing Gas.
4 .. Jars filling on the Shelf.
5 .. Jar filled on a dish

Gas received over Mercury.

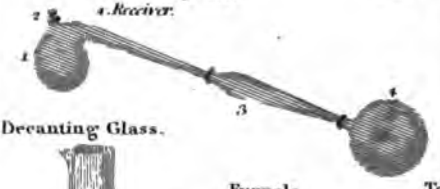
Mr. Knight's Apparatus for distillation.

1 . Furnace.
2 . Chimney.
3 . Capital of Still.
4 . Condensing Pipe.
5 . Refrigeratory.
6 . Worm cock.
7 . Water cock.

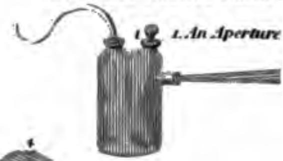
Cast Iron Mercurial Trough.

Tubulated Retort and Receiver.

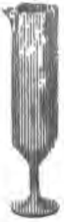
1. Retort.
2. Tubulure.
3. Connecting tube.
4. Receiver.



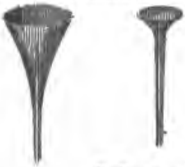
Retort and Woolfe's Bottle.



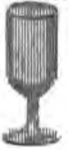
Decanting Glass.



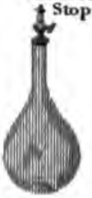
Funnels.



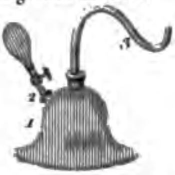
Test Glass.



Gas bottle w
Stop Coc

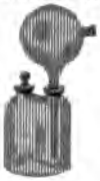


Apparatus for preparing Nitric Acid &c.

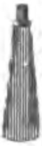


1. Vessel containing Nitrate of Potass.
2. Aperture for supplying Sulphuric Acid.
3. Tube for carrying off the Gas.

Balloon with Woolfe's Bottle.

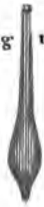


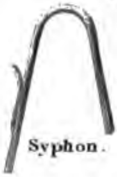
Test Phial for quantity of Carbonic Acid in any Substance.



Bent Fun

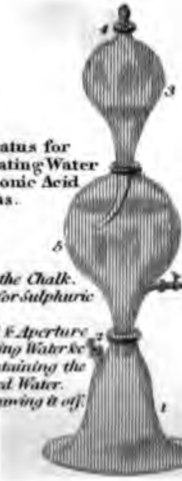
Dropping tube.





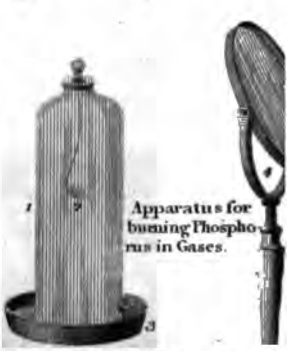
Syphon.

Apparatus for impregnating Water with Carbonic Acid Gas.



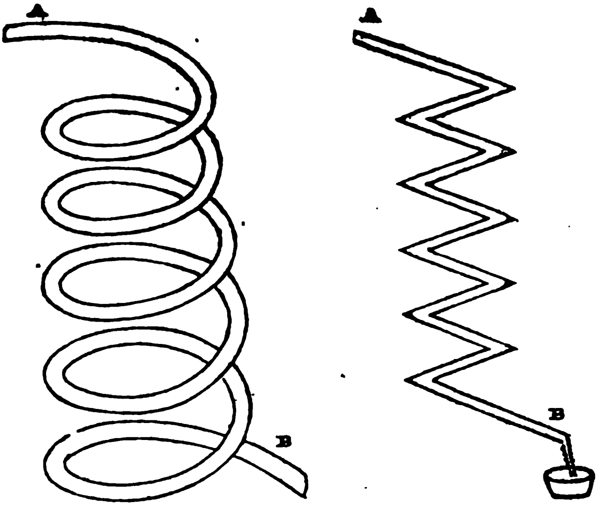
1. Vessel for the Chalk.
2. Aperture for Sulphuric Acid.
3 & 4 Vessel & Aperture for supplying Water &c.
5 Vessel containing the Carbonated Water.
6 Cock for drawing it off.

Apparatus for burning Phosphorus in Gases.



1. Jar containing Gas.
2. Metallic Spoon containing Combustibles.
3. Water Dish to prevent escape of Ga
4. Lens for setting them on Fire.

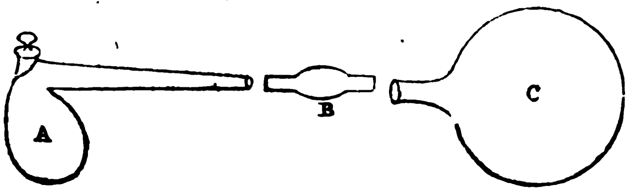
The worm may be either of a vermicular, or of a zig-zag shape. The following figures represent condensors of each of these forms.



A, A, Are the ends which communicate with the capital; B, B, the ends from which the condensed fluid escapes.

It is necessary to connect the different parts of a distilling apparatus in such a manner, that the vapour of the distilled product may not escape through apertures or chinks in the places where they are joined: for this purpose, substances of a soft nature, called lutes, are smeared over their joints.*

For many chemical purposes, retorts and receivers are used in distillation. The following cuts represent this apparatus in a disjointed state; that its parts may be properly understood.



A, Is the retort, having an aperture, called the tubulure, by which liquids may be supplied without taking the parts of the apparatus asunder; B, is a tube, into which the beak of the retort is to be inserted, and which communicates with the receiver, C. The apparatus may be seen together, in Plate 8.

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[*] The following lutes are sufficient for this purpose in most cases.

A mixture of pipe-clay, cut tow, and sifted sand, with water, is an excellent lute for corrosive substances.

Retorts are sometimes made of earth to resist the intense heat of fires. In the distillation of carburetted hydrogen gas, from coals, for the illumination of streets and houses, cast-iron retorts are used. Leaden retorts, as will be seen in a future page, are required for the distillation of fluoric acid.

Retorts are, however, generally made of glass, in order that the operator may see how the process is going on. This is absolutely necessary in nice and delicate experiments, as may be seen by the following one, which fully illustrates the mode of distillation by the use of retorts and receivers.

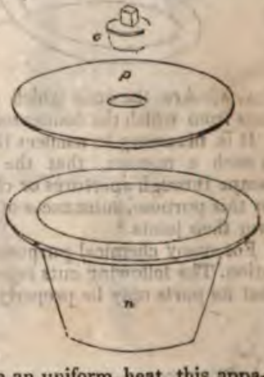
CXLI.

Process of Distillation with Retorts, &c.

Pour a quart of Ale into a Glass Retort, place it in a Sand-bath, and lute the Receiver, &c. to it. Soon after heat is applied, the Spirit will begin to come over. Separate the apparatus, as soon as the distilled liquor ceases to be spirituous.

Observations. In Chemical Laboratories, Retorts are much used for the concentration of acids; for the preparation of ethers, &c. &c. To prevent accidents, and to keep up a regular strong heat, the sand-bath is generally used.

This apparatus, which *n* in the annexed figure represents, is made of cast-iron, and fits exactly the aperture of the furnace shewn in page 100. The fire being kindled, the bath is to be nearly filled with fine sand, and the body of a retort placed deep in it, the sand being heaped up on all sides. When the sand becomes red-hot, the distillation will be at its height. *p*, Represents a lid for the bath, or for the aperture of the furnace, as occasion may require; *o*, is a stopper for the hole in the centre of the lid. For the distillation of substances which require an uniform heat, this apparatus is absolutely necessary.



A mixture of equal parts of muriate of ammonia and carbonate of lime with water, forms a very secure lute.

Finely pounded glass and the white of an egg, have been used both as a lute and a cement. They answer the former purpose very well.

Common putty, which is a mixture of oil and carbonate of lime, answers well in many cases as a lute.

Common clay, with or without sand, and mixed with some powdered carbonate of lime and water, is a lute which will stand a great heat.

A very good lute for common stills, for the distillation of aromatic waters, &c. is a paste made with linseed meal and cold water.

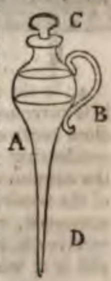
CXLII.

PROCESS OF DISTILLATION,
By means of the Common Still.

Put into a moderately sized Still, about a pound of Mint leaves (or any other herb, capable of affording an Aromatic Oil or essence,) with two gallons of Water; and place it on a fire or furnace: lute on the head, and connect the Worm with it. Now fill the Refrigeratory with Water; place a Recipient vessel under the Worm; see that the fire burns well, and that the whole apparatus is in proper order. In about half an hour, the Distillation will commence, and the Mint-water will trickle through the Worm into the Receiver, in a stream, which should never exceed the size of a thread, and it will be better not to urge the process, when conducted in this small way, beyond the degree at which the liquid drops in the most rapid manner, when it comes over more rapidly, there is danger of the fluid in the still *boiling over*. If this accident should happen, (its occurrence may be known by the liquid passing *warm* into the Receiver, though the Water in the *Refrigeratory* is cold), the heat of the furnace should be lessened, and the liquid which has boiled over should be set aside, and not mingled with that which has been properly distilled, as it would spoil it, and prevent it from being preserved by becoming mouldy. When the stream ceases to exhale the smell of Mint, the Distillation is to be discontinued, as all the volatile particles of the leaves have already come over.

Observations. In this way, essential oils, such as pepper-mint, rue, cloves, cinnamon, anise, turpentine, juniper, and otto of roses, are distilled from herbs submitted to a strong heat with water. These oils are called essential, or volatile, to distinguish them from such as will not rise by distillation:—accordingly, those which do not, (such as linseed, almond, castor, olive, and all animal oils,) are denominated fixed.

When oils are distilled, water generally comes over with them, and although from their levity they swim on the water, still they cannot be easily separated in the vessel into which they had at first flowed. To obviate this difficulty, a very useful instrument has been invented, called a separatory funnel, (see the annexed cut.) C, Is the upper aperture, into which the mixture is poured, and which has a glass stopper, which is to be withdrawn gradually, in order that much atmospheric pressure may not have the effect of forcing it out too rapidly, at the lower aperture, D; B, is the handle; and A, the body of water in the funnel, having the oil swimming on its surface. The oil, from being specifically lighter than the water, remains at the surface, and is to be prevented from escape, by putting in the stopper, C, just as all the water has run off.



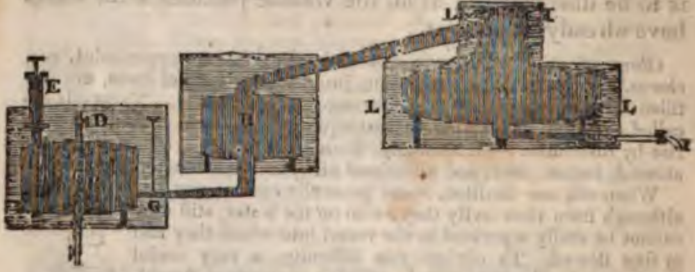
By distillation, all spirits and essential oils are obtained. Of the former, brandy is distilled from wine; rum from a fermented solution of sugar, or the juice of the sugar-cane; whiskey from a fermented liquor, made from potatoes, rye, oats, or barley; arrack, (an Asiatic spirit,) from rice, which has undergone fermentation similar to the above; and Chili, which is made in America and Africa, from a certain fruit. The Arabs distil a spirit, which they call Koumiss, from Mare's milk, which has undergone fermentation. Alcohol is the spirituous ingredient in all these distilled products. The purest alcohol contains no water; its specific gravity being .837. To obtain pure alcohol, the spirit from which it is distilled, must be mixed with dry muriate of lime, which, from its affinity for water, holds possession of it, whilst the spirit ascends. The alcohol cannot be deemed pure, until the muriate of lime is left dry in the still or retort.

Compound liquors, or cordials, such as gin, hollands, &c. &c. are distilled from fermented liquors combined with oil of turpentine Juniper-berries, &c.

Observations on Distillation, by a low heat, in close Vessels.

Those who are acquainted with the common mode of distillation, are, doubtless, aware of the unpleasant flavour, peculiar, more or less, to all distilled products. It is this which prevents, so long as the common operation is continued, the successful rivalry of British spirits with those of foreign manufacture.

A distilling apparatus has lately been invented, by which, a produce divested of any empyreumatic flavour or taste, may be obtained; by rendering it impossible for the matter in the still to be overheated, or burned to the bottom. This is accomplished by the transmission of the heat to the still, through the medium of a surrounding liquid, as may be seen by reference to the following engraving.



A, Is the Still; L, L, L, L, are the outer cases attached to it, by which it is surrounded with water; E, is an air-pump attached to the top of a close receiver, C, which, being worked, exhausts the still, A,—the close condensing vessel, B,—and the receiver, C. G, is a stop-cock, by which the communication between B, and C, may be closed, and the contents of the receiver drawn off, without impeding the operation; for while the stop-cock, G, is shut, the close condensing vessel acts as a receiver. The receiver is, of course, to be re-exhausted, if it has been opened while the still is at work, before the cock, G, is again opened: D, is an air-cock to admit air into the receiver previous to drawing off its contents; H, is the discharge-cock of the receiver; and I, is the discharge-cock of the still.

If the outer case in which the still is fixed, be placed on the fire, (as the still itself is in the usual mode of distilling,) it is evident, that the matter in the still can never be heated to a higher degree than 212°, the greatest heat of the surrounding water. But, in the improved apparatus, distillation is effected at a still lower temperature, (generally about 132°,) because the pressure of the atmosphere is removed from the surface of the liquid in the still by the air-pump; and, of course, from the regular application of so low a degree of heat, an agreeable flavour is secured to the distilled product.

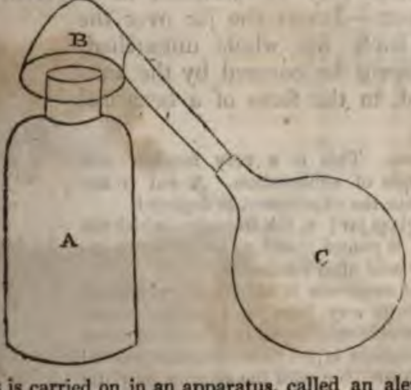
By the great reduction in the application of heat, an important saving of fuel is effected; and the vessels, from being less exposed to the action of violent fires, will be far more durable. A less quantity of cold water, for condensing the vapour in the condensing-vessel and receiver, is required than in common distillation: this, in many cases, will be found a material convenience, particularly in some of the West-India islands.

From the distillation being confined throughout the operation, to close vessels, the common loss by evaporation at the worm's end, is in this apparatus avoided, and an increase of produce is obtained. The produce of the improved apparatus has been submitted to the judgment of experienced persons, and most highly approved of. The apparatus itself may be seen at work at Mr. Tritton's manufactory, No. 63, Whitechapel, London.

It was at one time supposed, that fresh water might be obtained at sea by distillation; this plan, however, did not succeed, as the water still retained an unpleasant taste. Perhaps, if less heat were applied, on the principle of the foregoing improvement; and if the distilled water were afterwards exposed for some time to the air, this very desirable object might be attained.

OBSERVATIONS ON SUBLIMATION.

Sublimation, is the conversion of solid bodies into vapour, and their ascension in close vessels, when strongly heated.



This process is carried on in an apparatus, called an alembic, which the above cut represents: A, is the cucurbit, or boiler, into which the body to be sublimed is put; B, is the capital; and C, is the receiver.

These vessels are generally made of glass; but, like stills, they may be made of various materials, according to their intended use. Plate 4, exhibits this apparatus in action.

CXLIII.

SULPHUR SUBLIMES

When strongly heated in close vessels.

If pieces of brimstone are put into an alembic and heated to the temperature of 170°, they will be volatilized, and the Sulphur, in powder, will be found in the Capital and Receiver. If the Sulphur be heated 50 degrees more in a cup, that is to about 220°, it melts, and becomes quite liquid: and if heated to 500°, it will take fire, the flame having a bluish tint.

Observations. In the same way, various metals may be volatilised: among these are mercury, arsenic, and zinc. Even the most refractory metals, such as gold, silver, &c. are rendered volatile, by being exposed to the heat of the sun proceeding through a powerful burning lens. Electricity and galvanism have also the power of dissipating them in a state of vapour.

CXLIV.

BEAUTIFUL SUBLIMATION OF BENZOIC ACID

On the Branches of a Shrub.

Place a sprig of Rosemary or any other garden herb, in a glass jar, so that when it is inverted the stem may be downwards, and the sprig supported by the sides of the jar:—now put some Benzoic Acid on a piece of hot iron—so hot, that the Acid may be sublimed in the form of a thick white vapour.—Invert the jar over the iron, and leave the whole untouched, until the sprig be covered by the sublimed Acid, in the form of a beautiful hoar-frost.

Observations. This is a very familiar and pretty example of sublimation. A cut is annexed, wherein the experiment is depicted.

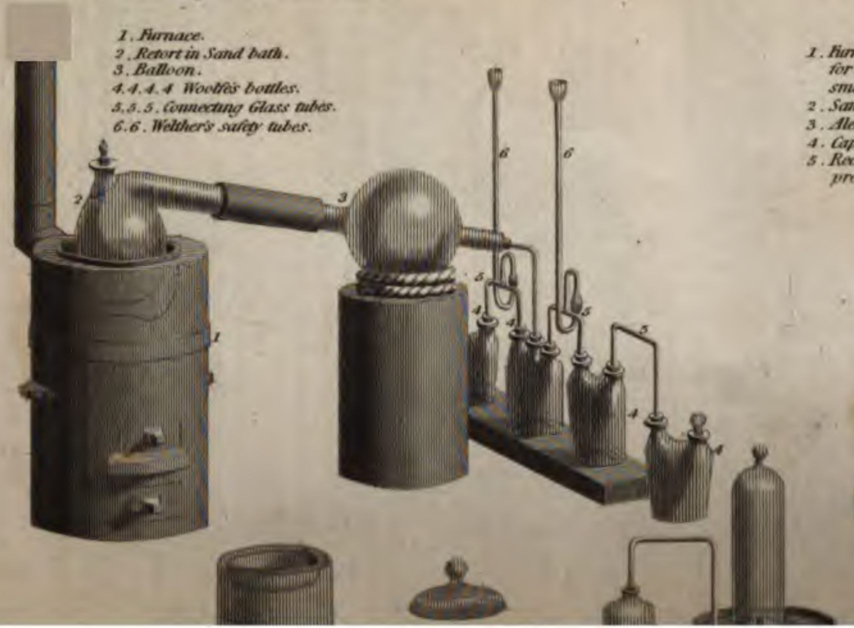
A, Is the glass jar; B, the iron upon which the benzoic acid is placed; and C, is the sprig covered by the acid after sublimation.

Muriate of ammonia is obtained by sublimation, in the large way, from the exposure of animal and vegetable matters to heat with common salt: the ammonia is set free from the animal substances to combine with the gaseous muriatic acid. Both are thus condensed or solidified, and sublimed into chimneys, where they assume the form of white cakes.

PLATE. IV.

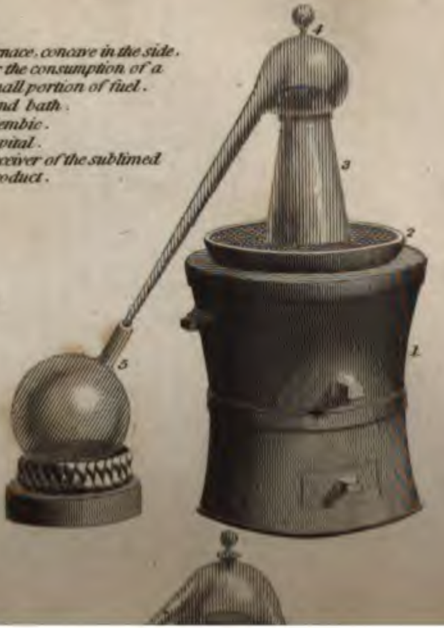
Woolfe's Apparatus for Impregnating water with Gases.

1. Furnace.
2. Retort in Sand bath.
3. Balloon.
4.4.4.4 Woolfe's bottles.
5.5.5. Connecting Glass tubes.
6.6. Welther's safety tubes.



Alembic for Sublimation.

1. Furnace, concave in the side, for the consumption of a small portion of fuel.
2. Sand bath.
3. Alembic.
4. Capital.
5. Receiver of the sublimed product.



OBSERVATIONS ON THE GENERATION AND USES OF STEAM.

Steam is water in a state of great expansion by heat: in this state it is elastic, and possesses astonishing mechanical and heating powers.

The bulk of steam at 212° is 1700 times greater than that of water, at the same temperature: consequently, it is no wonder that it should possess great expansive power, when machinery is set in motion and impelled by it: also, when in nature, bodies by resisting its influence, are rent asunder and thrown to great distances, as is the case in earthquakes and volcanic eruptions, which, probably, owe their destructive effects to this cause.*

CXLV.

EXPANSIVE POWER OF WATER WHEN FORMED INTO *Steam, shewn by the bursting of Candle-Bombs.*

Stick one of these in the tallow of a candle, so that the globular part shall be in contact with the flame. In the course of a few seconds, the liquid in the bomb being expanded by the heat, and converted into steam, will burst its confines with a loud report! scattering the glass in a thousand pieces, and extinguishing the candle.

Observations. Steam has long been deemed a most important agent in the arts and comforts of life. Its uses, however, have been confined to its expansive power in giving motion to machinery; to the diffusion of heat through houses, &c. &c., by being conveyed in pipes; and to the bleaching of linen. Our present state of knowledge does not enable us to apply steam to other purposes; but surely, we cannot be thought too sanguine, in anticipating its application to many other useful operations. We shall first notice its power in impelling machinery, and afterwards describe its uses and application in the diffusion of heat.

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* In September 1783, there was a volcanic eruption of Mount Hecla, in Iceland, surpassing every thing of the kind recorded in history:—the lava is stated to have spouted up to the perpendicular height of two miles, during the long continuance of two months; and to have covered 3600 square miles of ground, in some places 100 feet deep.

The hot springs of Ouachitta, in America, which have been known for many years, are situated on a stream called Hot-spring Creek, which falls into the Washitaw river eight miles below. They lie fifty miles south of the Arkansaw river, in Clark county, territory of Arkansaw, (lately Missouri), and six miles west of the road from Cadron to Mount Prairie on Red River.—The approach to the springs lies up the valley of the creek. On the right of the valley rises the hot mountain with the springs issuing at its foot; on the left, is the cold mountain, which is little more than a confused and mighty pile of stones. The hot mountain is about 300 feet high, rising quite steep and presenting occasionally ledges of rocks, it terminates above in a confused mass of broken rocks. The steep and otherwise steril sides are covered with a luxuriant growth of vines. The valley between this and the cold mountain is about fifty yards wide.—The springs issue at the foot of the hot mountain at an elevation of about ten feet above the level of the creek; they are very numerous all along the hill-side, and the water which runs in copious streams is quit hot; it will scald the hand and boil an egg hard in ten minutes. Its temperature is said to be the same as that of boiling water, but Dr. Andrews, of Red River, thinks it is not above 200° Fahr.

Observations on the Steam Engine.

The steam engine, or the apparatus in which steam is generated, (and to parts of which it communicates motion,) is now so commonly used, that description is, perhaps, unnecessary. We must, however, mention the principles of its action. The first is the expansive force of the steam, which causes the ascension of a piston in an iron cylinder. The piston having thus received an impulse according to the degree of expansion of the steam, and size of the apparatus, communicates it to any species of machinery which may be attached. The second principle is, the condensation, or escape of the steam by a valve; by which means, the piston, from its own weight, or other mechanical cause descends in the cylinder. The condensation is usually effected by letting cold water rob the steam of its latent heat, by which means it resumes the liquid form, and of course, occupies less bulk than before. An alternate motion may be given to the lever raised by the piston, by permitting its other extremity to be raised and depressed by steam issuing through another cylinder.

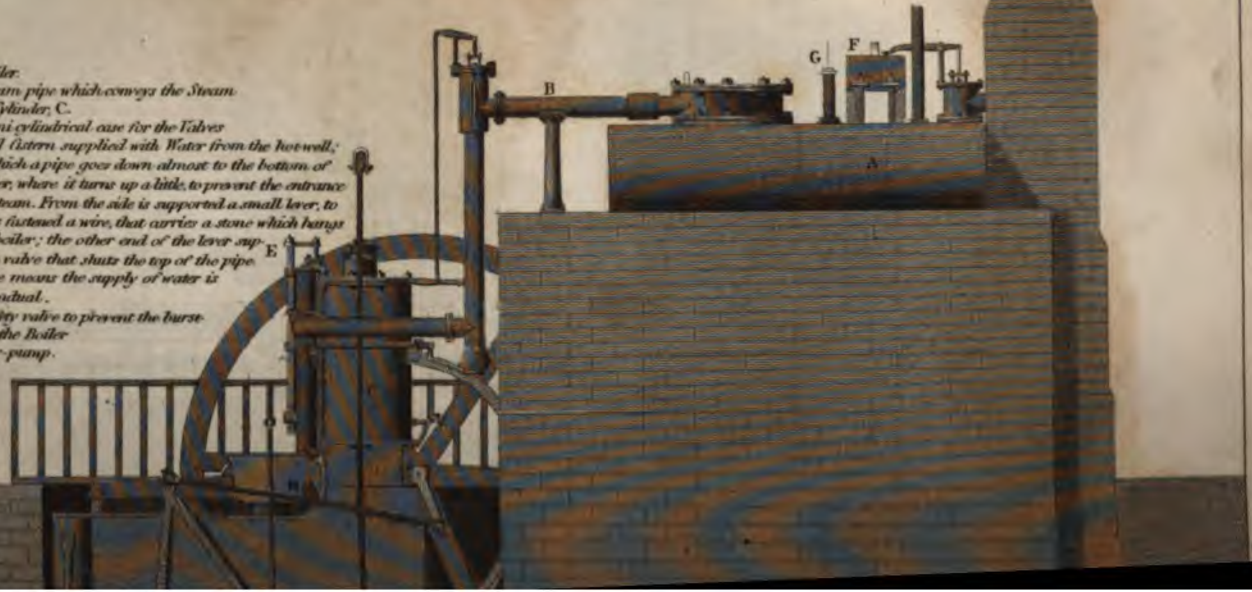
Plate 5 represents an engine of great power, used at Mr. Jackson's anchor-manufactory, Southwark; the various parts of which may be easily understood, by reference to the letters inscribed on it, and the following plate.

A description of the forms and uses of the steam-engine would be endless; already, by its extraordinary energies, the most astonishing works have been accomplished. Machinery of all kinds are set in motion; mines are emptied of their contents; carriages of various kinds are propelled on land; and ships are empowered to traverse the ocean by the use of steam-engines: there is little doubt too, if they were employed in aerostation, that for long voyages, steam-engine-balloons would speedily supersede the use of land and water carriage, and that their construction and ascension would delight more, from their real utility, than from the temporary amusement they now afford.

"Mr. Watt was the great improver of the steam-engine; but, in truth, as to all that is admirable in its structure, or vast in its utility, he should rather be described as its inventor. It was by his inventions that its action was so regulated as to make it capable of being applied to the finest and most delicate manufactures; and its power so increased as to set weight and solidity at defiance. By his admirable contrivances, it has become a thing stupendous alike for its force and its flexibility; for the prodigious power which it can exert, and the ease, and precision, with which that power can be varied, distributed, and applied. The trunk of an elephant that can pick up a pin or rend an oak, is nothing to it. It can engrave a seal, and crush masses of obdurate metal like wax before the sun; it can draw out, without breaking, a thread as fine as a gossamer, and lift a ship of war like a bauble in the air. It can embroider muslin and forge anchors; cut steel into ribands, and impel loaded vessels against the fury of the winds and waves."

PLATE V.

Steam Engine used at Jackson's Anchor Manufactory, Southwark.

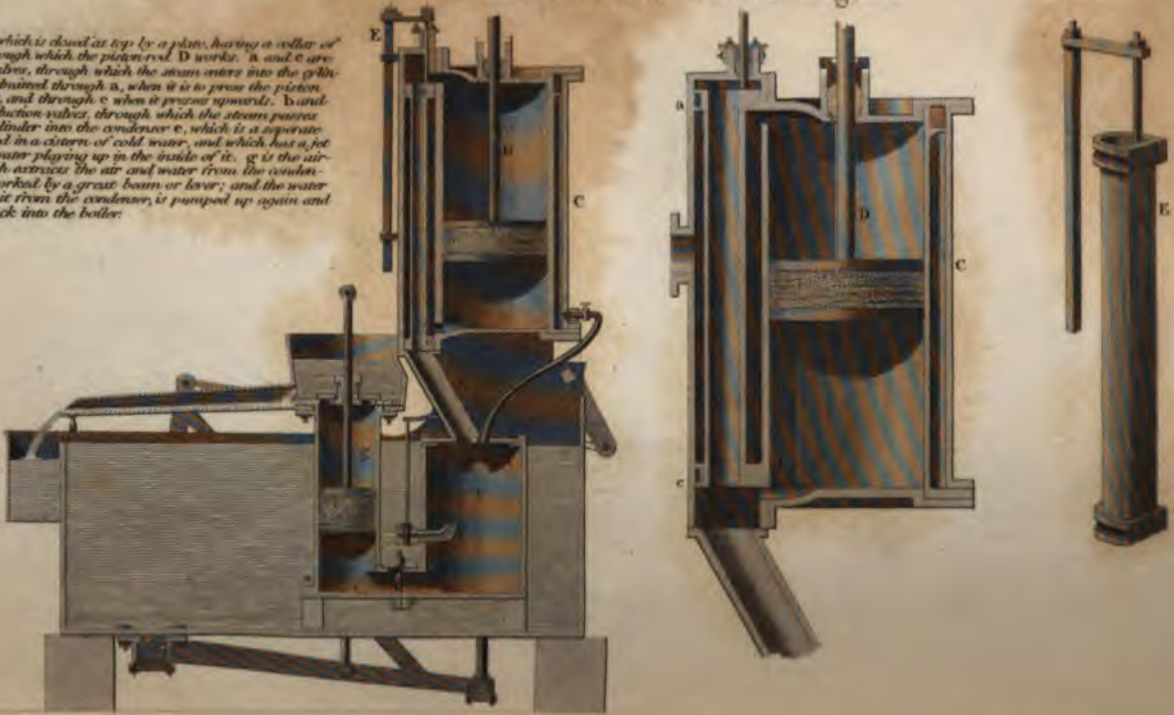


A *The Boiler.*
B *The Steam pipe which conveys the Steam to the Cylinder, C.*
E *Is a semi cylindrical case for the Valves*
F *A small Cistern supplied with Water from the hot well; from which a pipe goes down almost to the bottom of the boiler, where it turns up a little, to prevent the entrance of the steam. From the side is supported a small lever, to which is fastened a wire, that carries a stone which hangs in the boiler; the other end of the lever supports a valve that shuts the top of the pipe. By these means the supply of water is very gradual.*
G *The safety valve to prevent the bursting of the Boiler*
H *The Air-pump.*

PLATE VI

Section of Jackson's Steam Engine.

C. a Cylinder which is closed at top by a plate, having a collar of leathers, through which the piston-rod D *works.* a *and* c *are the steam-valves, through which the steam enters into the cylinder: it is admitted through* a, *when it is to press the piston downwards, and through* c *when it presses upwards.* b *and* d *are the eduction-valves, through which the steam passes from the cylinder into the condenser* e, *which is a separate vessel placed in a cistern of cold water, and which has a jet* f, *of cold water playing up in the inside of it.* g *is the air-pump, which extracts the air and water from the condenser: it is worked by a great beam or lever; and the water brought by it from the condenser, is pumped up again and brought back into the boiler.*



nism, likewise, 300 sabres are moved outside its port holes with the most perfect regularity; and, four times every minute, as many long spears are darted out with the most incredible force, and pulled back every time for a fresh emission.

The following advantages may be anticipated from the use of steam in the navigation of ships:—

1st. Vessels will not be obliged to wait for weeks or months for a fair wind, to the great loss of time and money.

2nd. Neither will they be becalmed at sea, for days and weeks together, in hot climates, to the great injury of the vessel and the health of the crew and passengers.

3d. Voyages may be performed within certain limited periods. Markets can be regularly supplied; the public will be benefitted, and the calculation of the merchant will not be disappointed.

4th. The vessel being constructed of great length and breadth, will be steadier in the water, and not liable to be strained by the operation of the wind upon masts and rigging. Goods will be preserved from injury, and passengers from inconvenience and danger.

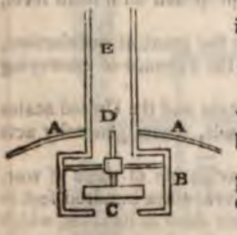
5th. The expence of the first cost of sails and rigging, and the annual repairs of the same, will be saved; and one third of the usual complement of men, for vessels of the same tonnage, will be sufficient.

6th. The value of such an agent as the steam engine, when the vessel has to contend with strong currents, on a rocky lee-shore, will be greatly appreciated. Many a valuable cargo, under such circumstances, will be saved from destruction.

As far as regards danger, to be apprehended from fire or explosion;—such measures are easily adopted, as to remove all grounds of fear on that account. (See the report of the committee of the House of Commons on the dangers to be apprehended from the use of high and low pressure steam engines in the various arts of life; and how these may be obviated, in *Tilloch's Philosophical Magazine.*)

As there is a prejudice against steam boats, and there have been too many just grounds for alarm, owing to the hardihood of the persons employed in the management of them, the following plan of a safety valve for the boilers of steam vessels will no doubt be approved.

As this valve is placed in the *inside* of the boiler, it cannot be overloaded by the engineer, which has been the cause of most of the accidents which have happened.



A. A. Is part of the top of the boiler.

B. A box, containing the valve, fixed in the inside of the boiler.

C. The valve, which is loaded according to the pressure necessary for working the engine.

D. A pin fixed to the top of the valve, and working in a socket, to keep the valve in its proper place.

E- The pipe for carrying away the overplus steam, which may be raised to any height, or turned into the chimney.

The dimensions will depend on the size of the boiler

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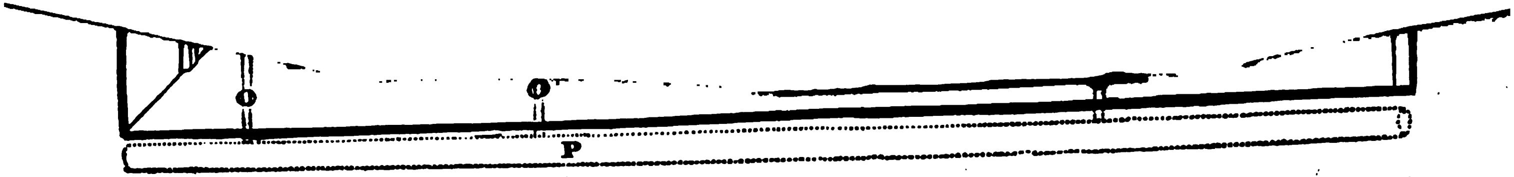
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OBSERVATIONS ON THE DISTRIBUTION OF HEAT BY STEAM.

The next important uses to which Steam is applied, are the Heating of Houses, &c. and the Ebullition of Liquids. To these it is well adapted, as in its condensation, or return to the liquid state, it gives out its superabundant, or latent, heat, to surrounding bodies.

The thermometer indicates no more heat in steam than that in boiling water; still its real heat is 800 degrees more; but this portion is latent in it, and is necessary to preserve it in the gaseous state: consequently when it comes in contact with the cold air in a room, or with a cold liquid in a vessel, it is itself condensed, and they become warm by combination with the heat which it had imparted to them. This heat, whilst it preserved the steam in the gaseous form was *latent*, but now it becomes *sensible*. Upon this principle is founded the

Application of Steam to the Heating of Houses, &c.

Steam is applied to this purpose in many manufactories in London, and in the provinces. The system has so far succeeded, and has been so variously improved, that there are in London several candidates who submit for public preference different means of generating and diffusing it. In consequence, this method of creating heat is much adopted. It is found, that all the rooms of a large house may be kept at a temperate or at an higher degree of heat, night and day, by the steam generated from a boiler of thirty or forty gallons, worked by one bushel of coals.

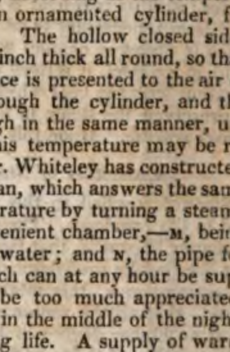
In some manufactories, the steam is carried through iron pipes around the skirting of the rooms; it being ascertained, that one foot surface of steam-pipe will warm two hundred cubic feet of air in a room. In some houses, steam is conveyed within the apartment, into the hollow sides of a copper cylinder, which can have any ornamental figure given to it. There is, in either plan, no dirt nor effluvia; and no possible danger exists, because the boiler may be worked in any out-building, at a low pressure, regulated by a valve.

A spirit of competition has been excited among the manufacturers of this apparatus, for domestic use; we shall confine ourselves to a description of the latest and most approved construction, and application of it, not only to the warming of houses, but to many other domestic purposes.

Mr. Whiteley, Rosamond-street, Clerkenwell, is in the habit of constructing the most complete apparatus of this kind, which has ever been offered to public attention. The annexed engraving will shew his mode of generating, diffusing, and operating with steam, and to what extent it may be carried from a boiler attached to a kitchen-range.

A, Is the boiler, occupying the back and left side of the kitchen range, or grate, and forming one entire vessel, which is acted on by nearly the whole of the fire. In common grates, this heat is wasted. By these means, the water is kept in a state of constant ebullition, as long as there is fire in the grate. The other side is formed into an oven, where meats, &c. may either be baked or roasted, by the passage of flame (through an apperture in the side) over their surface. B, Is the main pipe, conveying the steam to the other pipes, B, B, and I, which heat the washing tubs, steamers, bath, and all the apartments in the house. C, Is an hot plate, or stewing-stove;—it also serves to heat irons. D, Are steamers, standing on a dresser, in a recess;—this mode of cooking by steam is more cleanly and economical than that with boiling water. E, Is a hot closet under the dresser. F, F, Are the washing-tubs, into which steam-pipes pass; the water is thus heated in *wooden*, instead of metallic vessels. In this way, water may be boiled in a few minutes, in any vessel, such as a tea-kettle, or urn, by merely turning the cock of a very small steam-pipe immersed in it. On the same principle, G, is a wooden-trough for boiling linen, &c. &c. by steam. H, is a cistern, with ball and cock, to keep the boiler supplied with water. I, The steam and cold water pipes for supplying the washing tubs, according as the temperature for washing may be required. K, Is an ornamented cylinder, for heating apartments in any part of the house. The hollow closed sides of this cylinder, containing the steam, are an inch thick all round, so that the greatest possible quantity of heated surface is presented to the air of the apartment. The warm air ascends through the cylinder, and the rest of the air in the apartment passes through in the same manner, until the whole is of the same temperature:—this temperature may be regulated according to the degree required. Mr. Whiteley has constructed a box, shaped and ornamented like an Ottoman, which answers the same purpose. L, Is a bath, heated to any temperature by turning a steam-cock; the bath may be situated in any convenient chamber,—M, being an hydraulic pump, for the supply of cold water; and N, the pipe for conveying it. The possession of a bath, which can at any hour be supplied with warm water, by a family, cannot be too much appreciated, particularly in cases of sudden illness; as, in the middle of the night, such a remedy may be the means of saving life. A supply of warm water in the night-time, is always at hand by the apparatus we are now describing, as the boiler retains its heat for seven or eight hours after the fire is extinguished. O, O, O, O, Are the pipes for carrying away the waste water into the drain P.

The annexed engraving represents the steam boiler; the bottom of which is divided into three hollow parts, A, B, and C, which present the water in small portions, at one time, to the action of the fire. This mode has been found pre-eminently useful where steam is required to be generated with rapidity; and has been most succesfully applied to heating hot-houses, manufactories, and drying-rooms: also, to the boiling of paper-makers' vats, washing and brewing tubs, &c. &c. &c., by the application of steam, by means of pipes passing through them.



The fuel necessary to generate the steam, in the manner we have been describing, may consist of a mixture of small coals, and ashes, which, in London, will cost about six-pence for sixteen hours. At this cost of fuel, every purpose of culinary fires may be effected; as heating, boiling, washing, brewing, baking, drying, and even roasting.

The whole may be seen complete, and in constant use, at Mr. Whiteley's manufactory. Considering the ingenuity and labour of the invention; and the multiplicity of advantages to families, combined in so simple a manner and in so small a compass, we do not hesitate to give to the whole, our warmest approbation.

A steam apparatus has been recently erected at St. Pancras workhouse, where a boiler of sixty gallons heats a stone bath of four hundred gallons, several times in the course of a day; for bathing sick persons, boiling blankets, beds, &c. From the same boiler, is also boiled one eighty gallon copper for washing; one eighty-five gallon ditto for cooking; and one thirty-six gallon for the same purpose; all performed by one bushel of coals per day. Similar work is done at St. Andrew's workhouse, with three pecks of coals per day.

At Cheltenham, the late Mr. Thompson not only heated his baths with steam, but also the air of the dressing-rooms.

At Mr. Ramshaw's, Fetter-lane, a steam apparatus has been introduced for copper-plate printing, which supersedes the use of twelve noxious charcoal fires.* Steam has also been applied to the warming of hot-houses.

In the application of steam to the boiling of liquids, as at Whitbread's brewery, by means of a worm conveyed through the midst of the liquors, five or six hundred barrels of wort are boiled in half the usual time, and two chaldrons of coals are saved in one day. Steam has also been introduced into many other breweries. No other copper is requisite besides the steam-boiler; the wort and liquors being boiled in wooden vats. It is likewise used for the purposes of distillation.

The following is a summary of the advantages which will result from substituting steam in place of culinary fires, for the heating of houses, &c:

1st. Steam saves half the quantity, and three-fourths of the cost of coals or other fuel.

2d. Steam can be made to create any degree of temperature required.

3d. Steam diffuses heat equally throughout an apartment,---every side and every part being as warm as every other side and part; and the people in a room, are not (as with fires) frozen on one side, whilst they are scorched on the other.

4th. Steam, as diffused in metallic enclosures, creates neither dirt, dust, nor noxious odour.

5th. Steam is free from the dangers, which attend common fires: for no house can be set on fire by the heat of steam; and there is no hazard of the dreadful accidents which arise from the clothes of females and children taking fire.

6th. Steam warms not merely the room into which it is conveyed, but all the adjoining rooms; and if made to act in a cylinder at the bottom of a well-staircase, or in the hall of a house, it will increase the temperature of the whole house.

7th. Steam, by causing the heated air to ascend, promotes the ventilation of a room, and the renewal of the air, by means of an orifice and pipe in the upper part of that room.

8th. Steam renders chimneys and fire-places unnecessary; and will, therefore, diminish the expence of building houses.

9th. Steam will heat several small houses from a common boiler at a joint expence.

10th. Steam will warm the largest as well as the smallest apartments, and parts remote from the boiler, as highly as those near; that is to say, would warm the Cathedral of St. Paul's, and every remote corner of it, as completely as the smallest cabin.

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* For this meritorious attention to the health of his workmen, the Society of Arts presented Mr. Ramshaw with the Isis gold medal.

11th. Steam renders kitchens and fires unnecessary under the roof of a dwelling; as it can be conveyed from any out-building to a cooking apparatus.

12th. It puts an end to the use and employment of the wretched climbing-boy. In a word, the introduction of steam for generating and diffusing heat, is likely, not only to change the entire economy of our houses, but to promote comfort, health, cleanliness, and security, beyond all former anticipations of art or genius.

Expansion of Solid Bodies.

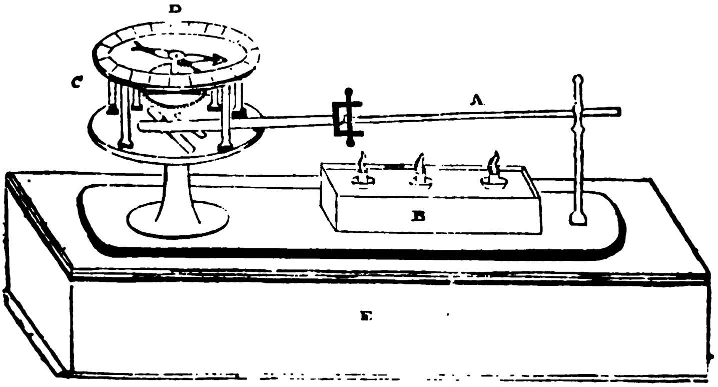
We have hitherto spoken only of the expansion of fluids by heat; but it is well known, and it will be presently seen, that solids also expand when heated.

CXLVI.

Heat causes the Expansion of Iron.

If an iron-ring be made of such a size, that an iron-ball (in a cold state) can just slip through it; and the ball be then made red-hot, the bulk will be so much encreased, that the dimensions of the ring will be too small for its passage. The diameter of the ball is, therefore, greater than before. Whence could this arise? The iron is expanded by the heat which entered it.

Observations. The following is the figure of an instrument well calculated to measure the comparative expansion of solid bodies: it is called a pyrometer. Expansion is denoted by the pressure of the heated body against a part of the machinery, which acting upon other parts, the whole receives a *multiplied* motion, which is marked by the index.

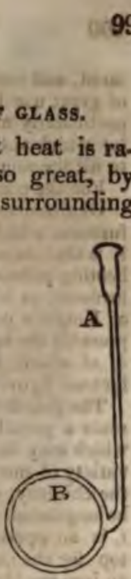


A, Is a metallic rod undergoing expansion. B, A treble lamp, filled with alcohol. C, The wheels, &c. acted on by the least pressure. D, The index and plate to note the degree of expansion. And E, is the stand for supporting the whole.

CXLVII.

HEAT CAUSES AN UNEQUAL EXPANSION OF GLASS.

The nature of glass is such, that when great heat is rapidly applied to its surface, the expansion is so great, by its slowness in communicating caloric to the surrounding parts, that the heated part distends and breaks. If then, a red hot wire be applied to any glass vessel, it will crack, and this crack, or fracture, may be carried round the vessel, so as to render the edge almost level, by moving the wire slowly on the surface. If the wire should cool before the fracture is complete, it must be again made red-hot. As it is often the case, that phials, flasks, receivers, &c. are broken in the progress of experiment, and are incapacitated for further use in that state, they may be converted to various uses, as evaporating dishes, &c. by merely applying over them a red hot iron-ring; the figure of which is annexed. A, Is a wooden handle to prevent the hand from being burned. B, Is the ring.



Observations. The art of making watch-glasses depends upon the employment of caloric, as a power which expands glass unequally. A glass globe is blown of sufficient size to permit five glasses being cut from it. When the globe is cold, a red-hot tobacco-pipe, or iron-wire, is run round. The model of the watch-glass drawn upon it; being the crack follows the point of the heated pipe or wire, until the circle is described, and the watch-glass drops out of its place. The other four are done in the same way. This contrivance is admirable, considering that it arose from what is generally supposed to be a bad property of glass: viz. fracture by heat too suddenly applied.

OBSERVATIONS ON FUSION.

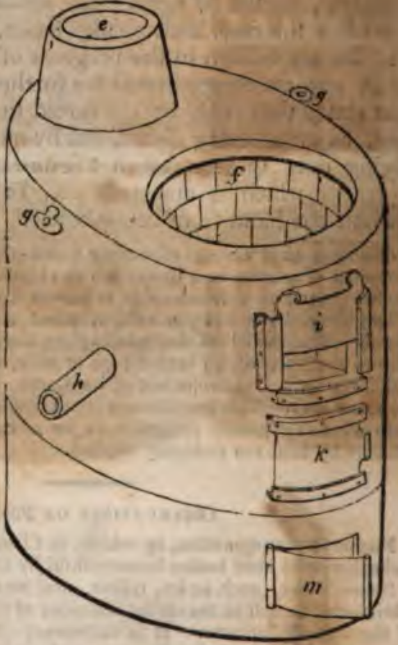
Fusion is that operation, by which, in Chemistry and the arts, Metals and other solid hard bodies become fluid by combination with heat.

Some bodies, such as ice, tallow, and wax, melt by a gentle heat; whilst others, such as the earths and some of the metals, resist the action of the hottest furnaces. It is customary, therefore, since the late improvements in chemical science, to submit these refractory substances to the action of a blow-pipe charged with hydrogen and oxygen gases; or to the agency of galvanism. The concentration of the solar rays, too, through a powerful burning-glass, is sometimes employed for this purpose.

Expansion is the general consequence of fusion, and contraction that of the return of bodies to a solid state: but there are exceptions to this rule. Bismuth, antimony, cast-iron, and some alloys, contract while fused, and expand when they become cold and solid. This exception is of great use in the arts where the above-mentioned metals are used; particularly in the case of an alloy of which printer's types are made, (of which antimony forms a part;) whereby it is fitted by its expansion to fill the mould so completely, as to receive the most exact impression.

For the common purposes of fusion, furnaces, crucibles, &c. are used.

Of furnaces there is a great variety: the most common is the blast furnace, which is urged by a large pair of bellows, and termed a forge; it is that used by blacksmiths. Reverberatory furnaces are used for heating metals, ores, &c. before they are placed in wind, or smelting furnaces, to be fused or reduced. See Plate 7. See also an engraving of Knight's portable furnace, in Plate 7. Likewise Plate 8, which represents the furnaces in the Laboratory of the Surrey Institution; figure 5, of which, is an annealing furnace, heated by the flame of the wind-furnace figure 4, in its passage to the chimney at figure 3.

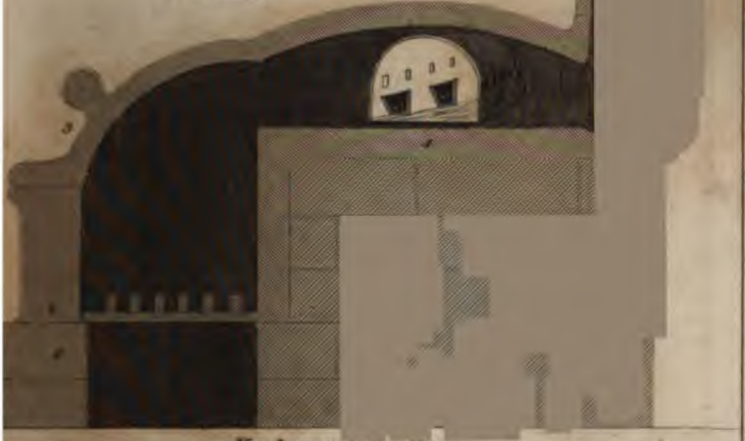


The annexed cut represents a portable furnace, which may be used for a variety of purposes. *e* is the chimney, which may be lengthened at pleasure; *f*, is an aperture at the top for the reception of an iron sand bath, (before described,) and for the admission of fuel; *g*, *g*, are rings for supporting iron pillars, which have a wire passing across at the top, for suspending an evaporating-dish, or any other vessel above the fire; *h*, is a tube or gun-barrel, passing thro' the furnace; this tube, (as will afterwards be seen,) is for the production of hydrogen gas. When the furnace is used for other purposes, the tube is to be withdrawn, one hole may be stopped, and into the other the pipe of a pair of bellows may be inserted. *i*, Is an aperture with a sliding door, for the reception of a muffle: *k*, is a door, by which a crucible, &c. may be placed in the furnace; and *m*, is the ash-pit. This furnace, taken altogether, is, perhaps, the most complete for a variety of useful purposes, that ever was invented. There is a furnace (on a different principle from any of the foregoing) exhibited in Plate 4, which is well calculated for the consumption of a small quantity of fuel. It is wide at the top and bottom, and narrow in the middle so as to afford sufficient room for the crucible, which on this plan is very strongly but economically heated.

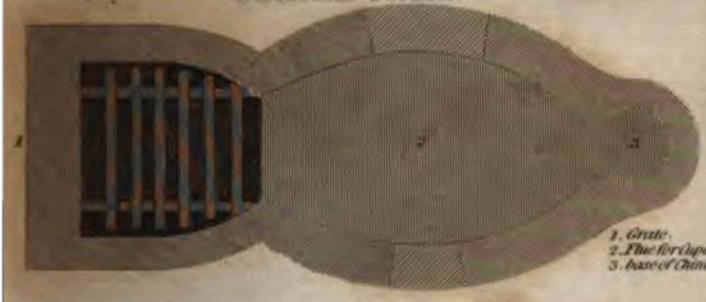
PLATE. VII.

Section of an Air, or Wind Furnace.

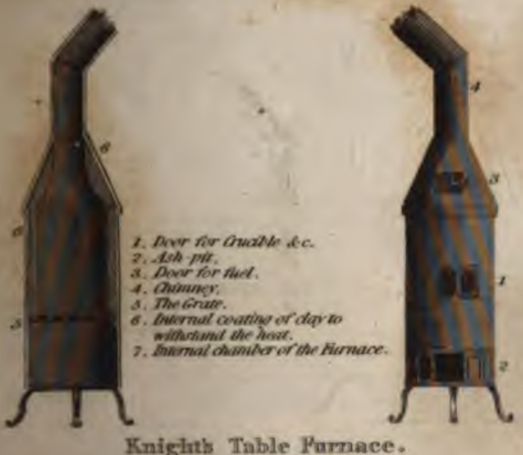
1. The Grate.
2. The Ash-pit.
3. Fire-lid for admission of Fuel.
4. Flue for admission of Muffle and Cupels.
5. Chimney.



Horizontal Section.



1. Grate.
2. Flue for Cupel &c.
3. base of Chimney.

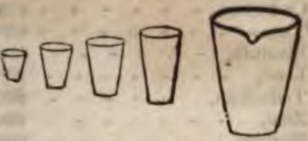


1. Door for Crucible &c.
2. Ash-pit.
3. Door for fuel.
4. Chimney.
5. The Grate.
6. Internal coating of clay to withstand the heat.
7. Internal chamber of the Furnace.

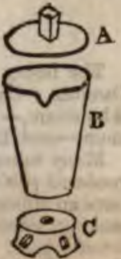
Knighth Table Furnace.

Mr. Gill has used pumice-stone as a furnace for performing experiments in fusing metals. Its light and porous nature, and of course, its very slow conducting power for heat, suggested the use of this substance. He made hemi-spherical cavities, of about an inch and a half only in diameter, in two small pieces of pumice stone; and, after making side orifices into the hollow cavities thus formed, to introduce a blast of air, he filled them with charcoal, putting in also a small piece of copper, and fitted them together. On igniting the furnace, and employing a pair of common hand bellows, he soon raised the temperature of the fuel to an extraordinary degree of vehemence; and found the copper was completely fused with that very small quantity of fuel only. This apparatus has since been improved by Mr. Gill, and has also been used in the laboratory of the Royal Institution. It promises to be of considerable utility to those gentlemen and others who are desirous of performing chemical experiments in a parlour upon a table, and on a small scale: but we think that the uses of pumice stone might be still further extended by its being pulverised, and caused to surround furnaces of large dimensions, where the intensity of the heat wanted is great, and where the prevention of its escape is of importance.

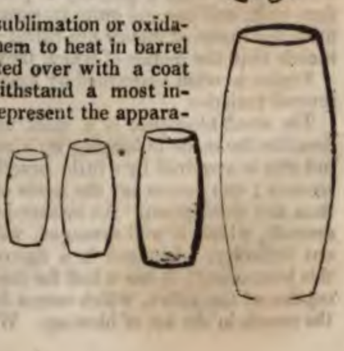
Crucibles, which are made of baked earths, &c. are of various shapes and sizes. The most common are of the annexed form. These contain the metals or other substances to be fused, and from their power of resisting fusion themselves, except when submitted to a very extraordinary heat, they answer all the common purposes of melting metals and of reducing their oxides in quantity sufficient for every purpose of chemical experiment.

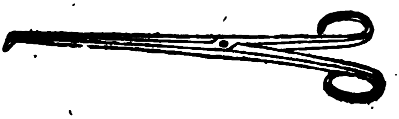


When substances in a state of fusion are apt to oxidate, to sublime, or to evaporate; and by this loss of quantity are liable to defeat the desired end of experiment; the crucibles containing them have lids, which may be either slightly or strongly luted to them. Annexed is a figure of one of these: A, is the lid; B, the crucible, and C, a stand to support it in the furnace. In the reduction of arsenical ores, and in the fusion of zinc and other metals, volatile at low temperatures, these covered crucibles are absolutely necessary.



Another mode of preventing the sublimation or oxidation of fused metals, is to submit them to heat in barrel formed crucibles, which may be luted over with a coat of clay and sand. This coat will withstand a most intense heat. The annexed figures represent the apparatus in question. These crucibles are those recommended in experiment 115 for the preparation of charcoal.





Annexed is the figure of an iron tongs, or forceps, made use of by chemists and workers in metals to remove crucibles from the furnace.

The operation of melting or fusing metals must be so well understood even by the most inexperienced, that it would be useless to waste time in describing it. Instead therefore of a series of experiments on the subject, the reader is presented with the following

TABLE OF THE ORDER, AND DEGREES OF HEAT, IN WHICH *Metals are fusible.*

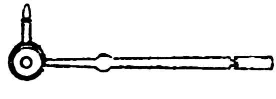
Fahrenheit's Thermometer.		Wedgewood's Pyrometer.	
Mercury,	— 39°	Silver,	22°
Potassium,	+ 136°	Copper,	27°
Sodium,	194°	Gold,	32°
Arsenic,	206°	Cobalt,	130°
Selenium,	214°	Iron,	158°
Cadmium,	436°	Nickel,	160°
Tin,	442°	Manganese,	160°
Bismuth,	476°	Platinum,	170°
Lead,	612°	Palladium,	170°
Tellurium,	620°	Chromium,	170°
Zinc,	680°	Molybdenum,	170°
Barium,	700°	Uranium,	170°
Antimony,	810°	Titanium,	170°
		Tungsten,	170°
		Tantalium,	170°
		Rhodium,	180°
		Iridium,	180°

The fusing points of the following thirteen metals are unknown.—Osmium,—Calcium,—Magnesium,—Strontium,—Yttrium,—Cerium,—Aluminum,—Glucinum,—Zirconium,—Ammonium,—Lithium,—Silicium,—and Thorinum.

Many substances, infusible (in the common modes) by themselves, are rendered perfectly fusible, by the addition of other substances which have an affinity for them. This is well exemplified in the art of glass-making, where flints, sand, or silicious earth, will not fuse by a most intense heat, until a quantity of potass be added: the whole mass will then melt, and become quite transparent: substances employed to facilitate the fusion of metals are called fluxes. Alloys are generally more fusible than the metals of which they are composed.

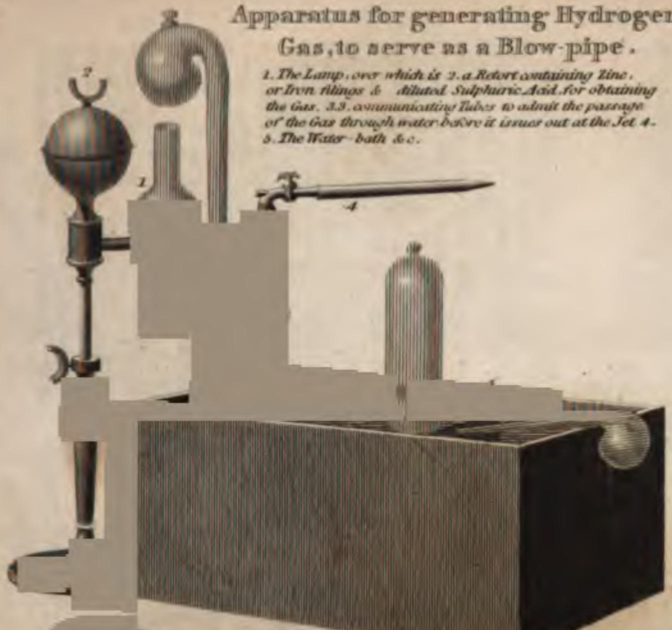
Fusion is often performed by means of blow-pipes, of which there are several varieties.

The small blow-pipe is a most useful instrument. It is difficult to describe the mode of keeping up a continual blast for a minute or two • but this is acquired by a little practice, and any one can blow for a few seconds; one lesson on the mode of using it will be more satisfactory than any description. An intense heat may be produced by it in a few seconds, which, if well managed, will melt most of the metals, &c. without difficulty. Annexed is a figure of this instrument: it has a ball for the reception of the saliva, which comes from the mouth in the act of blowing. Were

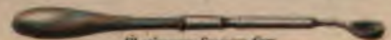


Apparatus for generating Hydrogen Gas, to serve as a Blow-pipe.

1. The Lamp, over which is 2. a Retort containing Zinc, or Iron filings & diluted Sulphuric Acid, for obtaining the Gas. 3.3. communicating Tubes to admit the passage of the Gas through water before it issues out at the Jet 4. 5. The Water-bath &c.



Double-blast



Platinum Spoon for fusing Metals &c.

Knight's Modification of Woolfe's Apparatus.

1.1.1.1. Three Glass Vessels which fit each other by grinding.

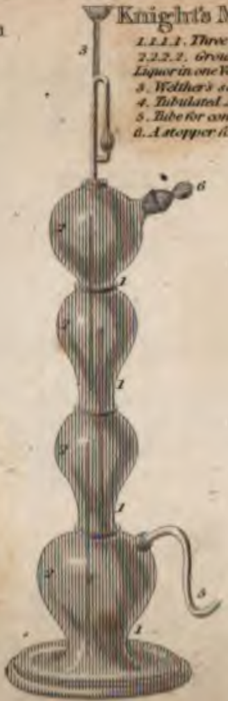
2.2.2.2. Ground Glass tubes whose upper ends stand above the surface of the Liquor in one Vessel whilst the lower ones reach nearly to the bottoms of those beneath.

3. Welther's safety tube to prevent absorption of Air.

4. Tubulated Aperture for admitting the neck of a Retort &c. when necessary.

5. Tube for conveying the Gas under a Bell Glass, over Water or Mercury.

6. A stopper for occasional purposes.



Alcohol Blow-pipe.

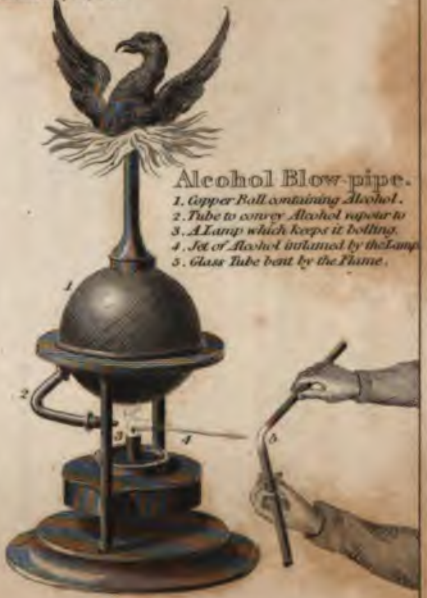
1. Copper Ball containing Alcohol.

2. Tube to convey Alcohol vapour to

3. A Lamp which keeps it boiling.

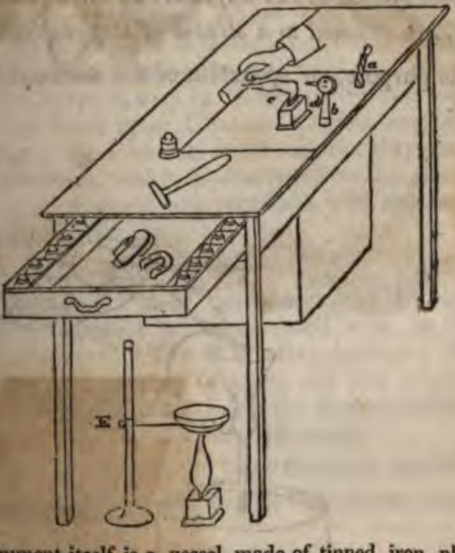
4. Jet of Alcohol inflamed by the Lamp.

5. Glass Tube bent by the Flame.



it not for this precaution, the damp would weaken the flame. The substances submitted to the flame must be small, not larger than a pepper-corn; disappointment frequently occurs from attempting to melt larger particles. See further description of this instrument in the Chapter on Tests.

The hydraulic blow-pipe, generally forms a part of a chemical or mineralogical apparatus convenient for the performance of experiments on a small scale. The following figure represents it as a fixture in a table fitted up with chemical tests, &c., in which state the whole apparatus may be had at Mawe's Mineralogical Repository.



The instrument itself is a vessel made of tinned iron plate, in the form of a parallelopipedon, which must be half filled with water. In it a partition is so placed, as to divide it into two chambers, having a vacancy at the bottom. A tube is placed in the corner A, so that by blowing down, the water becomes displaced from one chamber into the other, and acts with such pressure through the vacancy, as to force a continued stream of air through the nozle B. This being directed across the flame of the lamp C, a jet of heat is produced equal to a forge. The substance to be fused or the mineral to be examined, should be small, and placed on a piece of charcoal, then held in contact with the point of the flame. By keeping the water at the highest pressure, the greatest degree of heat is produced. The stream of air may be increased, diminished, or stopped, by turning the valve D. E, Is a stand supporting a small evaporating dish over a lamp.

The alcohol blow-pipe is really an ingenious and useful instrument; see plate 9. The alcohol in the brass globe is boiled by the heat proceeding from the flame of the lamp placed underneath: this causes expansion, or formation into vapour, which issuing out at the jet, is ingeniously made to pass through the same flame; whereby, from its inflammability, a stream of most intense heat is made to play upon any substance, submitted to its influence. As long as there is any alcohol in the globe, it will be rendered gaseous.

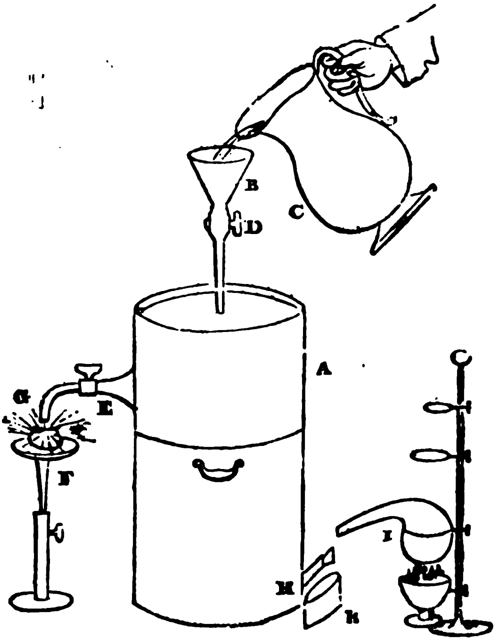
Blow-pipes are sometimes charged with gases in a separate or combined state, so as to support great heat for the fusion of refractory substances. Thus when a stream of oxygen gas descends on a red hot body, the combustion will be intense; consequently when another body is placed upon the burning one, fusion, or combustion is inevitable.

CXLVIII.

FUSION OF METALS ON IGNITED CHARCOAL,

When exposed to a stream of Oxygen Gas.

For this purpose, an apparatus of the annexed figure has been used.



Pour water in at the funnel B, until the japanned vessel A be quite full; then, after having shut the cock D, apply rather loosely the retort I, (charged with materials for procuring Oxygen Gas,) over the lamp, to the aperture H.

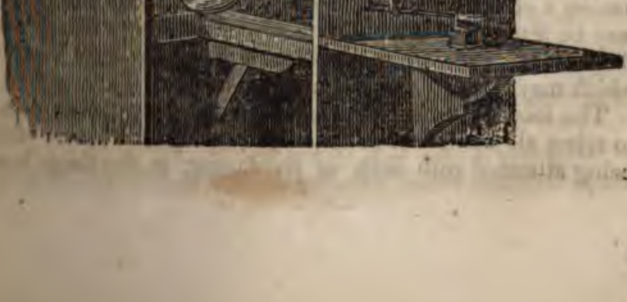
When the Gas begins to ascend, the Water will escape through the same aperture, and fall into the vessel K; when the vessel is quite full of Gas, the aperture is to be corked, the Gas being fit for use. When intended to be used, elevate the stand F, within two inches of the jet G, and put whatever substance is to be fused on a piece of ignited Charcoal in a shallow platinum vessel like a saucer, which is to be placed on the stand. When all things are thus ready, turn the cock E, of the jet upon the Charcoal, &c.; also the cock D; and immediately afterwards pour Water from a pitcher into the funnel B. As the Water is poured in, the Gas rushes out, and this will continue to be the case until the vessel is again full of Water, when it may be charged with Gas as before.

Metals are fused upon Charcoal in this manner in the globular form; the Charcoal itself with the Oxygen forming Carbonic Acid Gas, which is dissipated in the atmosphere. A portion of the Oxygen also combines with the metal, and converts it into an Oxide.

It remains, now for us to describe one of the most generally useful instruments to be operated with, in the whole practice of chemistry. This is the *Oxy-hydrogen Blowpipe*, (charged with one part of Oxygen, and two of Hydrogen Gas,) which is capable of obtaining the highest temperatures, and of fusing the most refractory substances.

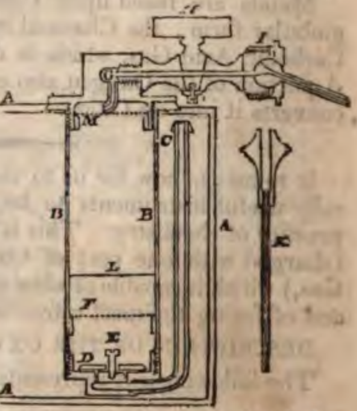
DESCRIPTION OF THE OXY-HYDROGEN BLOWPIPE.

The following cut represents this instrument in action.



A, B, Is a deal screen one inch and a quarter thick, reaching from the floor to the cieling of the laboratory; it is so constructed, that A, opens as a door, whilst B, remains fixed. C, Is the pump for exhausting the common air, and condensing the gases, by means of a piston. D, Is the metallic box of the Blow-pipe, for containing the condensed mixed gases. E, Is the bladder, containing the gaseous mixture for compression. F, Is the hand of the operator upon the stop-cock of the jet, on the outside of the screen. G, H, Is a glass or brass tube for the jet. I, is the spirit-lamp for igniting the gases.

The following is a figure of the minute parts of the Blow-pipe.



A, A, A, Is the box for the Gases. B, B, Is a piece of brass tube, closed at the bottom, called the trough, which is fixed air-tight, into the box. C, Is a small tube in the interior, which, commencing near the top, is inserted into the bottom of the trough; two or four holes are made from the trough into this tube, and open a communication to the Gases in the box. D, Is a circular flat valve, lined with oiled silk or leather. E, Is a central pin, which covers the holes, and prevents the passage of any thing from the trough into the box. F. Is an intersection of the trough by fine wire-gauze. G, Is a small chamber, (in the cap of the trough, which screws on air-tight,) communicating by a fine tube with the interior of the trough; and just below the orifice of this tube, is a second piece of very fine wire-gauze. H, Is the stop-cock, which connects the cap with a jet pierced, having a circular motion, I, and to this, various tubes, as K, may be fitted. A piece of fine wire-gauze covers the end of the tube at C, to stop the passage of any thing from the box, which may prevent the action of the valve.

The mode of rendering the use of this instrument safe, is to reject all jets but such as are of a very fine bore; these being attended with little or no danger, as the flame is arrested in them, by the minute diameter of their passages On the contrary, when jets of large diameters are used, they are very liable to a recession of the flame into the box, and, consequently, to the complete destruction of the apparatus, and the hazard of the operator's life. But as extremely high temperatures are sometimes necessary for the fusion of refractory bodies, tubes of one-sixtieth of an inch in diameter are absolutely necessary. To prevent injury to the operator, when these tubes are used, Dr. Clarke, of Cambridge, has invented a safety-screen, through which the jet passes to the body under operation; and we are happy to add, that the invention has hitherto completely answered its purpose.

When the instrument is to be used, the reservoir should be exhausted of the common air, by means of the syringe, and then filled with the Gases; after which, water should be poured into the trough to about I; the Gases may then be condensed into the box, by applying the piston vertically; and by their own elastic force, they will pass through the tube, the water, and the various screens of wire-gauze, and issue out at the jet.

When the inflammation, by the use of a very large jet, or of a slow current through a small one, passes backwards, it is generally arrested by the screen at M; and when it does pass it, it merely explodes the small portion of Gas in the upper part of the trough, and does no harm; and the valve D, prevents the water from being propelled into the box.

Dr. Clarke, in a letter to Dr. Thomson, says, that in using the Gas Blow-pipe, two precautions are necessary:—First, the operator, before igniting the Gas, should apply his ear to the apparatus, (gently turning the stop-cock of the jet at the same time,) and listen to determine, by the bubbling noise of the oil, whether it be actually within the safety cylinder. The oil may be drawn into the reservoir whenever the piston is used, if the stop-cock below the piston be not carefully shut, before the handle is raised. If there have been a partial detonation in the safety-cylinder, as sometimes happens, when the Gas is nearly expended, this precaution is doubly necessary, to ascertain whether the oil has not been driven into the reservoir, because an explosion of the whole apparatus would be extremely probable. Using this precaution, the diameter of the jet may be so enlarged as to equal one-twenty-fifth of an inch.

Secondly, if, with this diameter, the heat of the flame be not sufficient to melt a Platinum-wire, whose diameter equals one-sixteenth of an inch, the operator may be assured his experiments will not be attended with accurate results. The melting of Platinum-wire ought to be considered as a necessary trial of the intensity of the heat, which should be such, that this wire not only falls in drops before the flame, but also exhibits a lively scintillation, resembling the combustion of Iron-wire exposed to the same temperature.

"It must," he says, "have appeared very remarkable, that while the reduction of the Earths to the metallic state, (and particularly of Barytes,) was so universally admitted by all who witnessed my experiments with the Gas Blow-pipe in Cambridge; the experiments which took place at the Royal Institution for the express purpose of obtaining the same results, totally failed. This will, however, appear less surprising, when it is added, that my own experiments began, at length, to fail also. In the month of April 1817, owing to causes I could not then explain, the intensity of the heat was so much diminished in the flame of the ignited Gases, that I was sometimes unable to effect the fusion of Platinum-wire, of the thickness of a common knitting-needle. The blame was, of course, imputed to some impurity, or want of due proportion in the gaseous mixture; when, to our great amazement, the intensity of the heat was again restored, simply by removing a quantity of oil which had accumulated in the cap of the safety-cylinder, and which had acquired a black colour. About this time Dr. Wollaston arrived at Cambridge, and was present at some experiments, in company with the Dean of Carlisle and our Professor of Chemistry. Dr. Wollaston brought with him some pure Barytes. It was immediately observed, that with this newly prepared Barytes there was no possibility of obtaining any metallic appearance. The Barytes deliquesced before the ignited Gases, and drops of a liquid caustic matter fell from it. Hence, it became evident, that the failure here, and at the Royal Institution, might be attributed to the same cause; namely, the impurity of the Barytes, which proved to be in fact an Hydrate; its reduction to the metallic state, before the ignited Gas, being thereby rendered impracticable."

In Mr. Hare's (of Philadelphia) Blow-pipe, the Gases are not in mixture till they are brought together at the point of emission; "consequently" says Mr. Tilloch, "the operator is completely secured against any danger from an explosion; and it must be obvious, that by having two condensing vessels for the Gas reservoirs, every result can be obtained, which the united Gases from one vessel can possibly yield; for by means of a cock at the efluxion, the Gases may be regulated, till any required proportion of mixture or effect is produced."

The following are some of Dr. Clarke's Experiments on various Substances by the action of the Oxy-Hydrogen Blow-pipe.

CXLIX.

COMBUSTION OF THE CARBONACEOUS SUBSTANCE *Which floats on Pig-iron.*

When this substance was brought, *per se*, into contact with the ignited Gas, scintillations ensued, resembling the sparks thrown out by the firework, called *a flower-pot*; but on a smaller scale. When placed upon Charcoal, the same appearance takes place, until fusion begins, when a bead of metal is formed upon the Charcoal; and, as soon as this begins to boil, such a rapid combustion takes place, that the whole of the metal seems to be sent forth in a volume of sparks.

Observation. The bead exhibits to the file a bright metallic lustre like iron;—both before and after fusion, it is magnetic.

CL.

FUSION AND COMBUSTION OF CARBURET OF IRON.

Dr. Clarke selected a small fragment, and brought it into contact with the ignited Gases; its fusion immediately ensued, being accompanied, at the same time, by that vivid scintillation which was remarked in the preceding experiment, and which denotes the combustion of metallic bodies, especially of Iron and Platinum. No change of colour was, how ever, to be observed in the flame; the light, as usual, was intense.

Observations. Upon examining the appearance of plumbago after fusion, its surface was covered with innumerable minute globules, some of which were limpid and transparent; others were of a brownish hue; and the larger globules jet black; and seemed to exhibit a dark metallic lustre; but being so exceedingly minute, it was difficult to ascertain their real nature. They sunk in naphtha, disengaging bubbles of gas. Water produced no change in their appearance; they fell rapidly to the bottom, and remained there without alteration.

CLI.

Reduction of Oxide of Tin,

Attended by Combustion.

Wood-tin exposed to the ignited Gases, communicates a beautiful blue colour, like that of violets, to the flame. This, Dr. Clarke says, has not been before noticed.

If a pair of Iron forceps be used as a support, the Iron becomes covered with an Oxide of Tin, of incomparable whiteness. The fusion is rapid; and if the Wood-tin be placed upon Charcoal, the metal will be revived in a pure and malleable state.

CLII.

Reduction of Oxide of Iron

Attended by Combustion.

In this experiment, Dr. Clarke made use of Wood-iron, or fibrous red Hæmatite. It was placed upon Charcoal, and instantly fused; being reduced to a bead, which began to burn, like Iron-wire, by continuance of heat.

CLIII.

Fusion of Platinum.

The largest drops which have fallen from melted Platinum-wire, when exposed to the utmost heat, weigh ten grains; but Dr. Clarke obtained drops of metal weighing fourteen grains, when the current of gas was diminished so as not to let the metal run off too quickly from the wire. By placing several globules upon a piece of Charcoal, and suffering the whole force of the gases to act upon them, the metal is made to boil, and they all run together in one mass. In this way Dr Clarke has melted more than 200 grains of Platinum into a single brilliant metallic globule.

CLIV.

Combustion and volatilization of Tellurium.

When Tellurium is placed upon charcoal, and acted upon by these gases, it inflames with violence, accompanied by detonation, exhibiting a very beautiful flame. It is then volatilised in the form of a greenish yellow vapour, having a very disagreeable odour.

CLV.

Combustion and volatilization of selenium.

The action of the ignited gases on this new metal, causes rapid volatilization, and the metal as it arises gives a beautiful blue colour to the flame; at the same time the vapour has a strong odour of horse-raddish.

CLVI.

COMBUSTION AND SCINTILLATION OF ANTIMONY.

If, when this metal is in a state of ebullition on Charcoal, it be thrown upon a deal-board, or on the floor, it will divide into innumerable fiery globules, which burn with a vivid flame and brilliant scintillation.

CLVII.

FUSION AND SCINTILLATION OF IRON AND IRON-FILINGS.

When these were put upon Charcoal, and acted upon by the ignited gases, they were speedily in a state of active ebullition, and gave out a most vivid light, accompanied by beautiful scintillations.

CLVIII.

FUSION AND COMBUSTION OF COPPER.

Copper placed upon the Charcoal, boiled and burnt rapidly, giving out a delicate green flame.

CLIX.

COMBUSTION OF GOLD.

If a slip of gold be exposed to the action of these gases in a state if ignition, it will burn with a brilliant green flame.

CLX.

COMBUSTION OF SILVER.

When a piece of silver is put on a piece of Charcoal, before the jet of the compound blow-pipe, it burns with a light green flame.

CLXI.

FUSION AND COMBUSTION OF CRYSTALLIZED *Phosphate of Lime.*

This salt did not decrepitate. It was phosphorescent, and fused into a black slag; depositing on an iron forceps, a cupreous coloured powder. It scintillated with a reddish-coloured flame. Upon filing the slag, Dr. Clarke observed a globule of white metal, resembling silver, which does not alter by exposure to the air.

Mr. Hare's experiments on Earths, &c. with the Oxy-Hydrogen Blow-pipe.

CLXII.

FUSION OF SILEX, ALUMINE, AND BARYTES.

Finely powdered silex was moistened with water; it became agglutinated by the heat, and was then perfectly fused into a colourless glass.

Alumine was perfectly fused into a milk-white enamel.

Barytes fused immediately, with intumescence, owing to water; it then became solid and dry; but soon melted again into a perfect globule, or greyish-white enamel.

CLXIII.

FUSION OF STRONTITES, GLUCINE, AND ZIRCON.

Strontites placed upon the Charcoal and exposed to the inflamed gases, exhibited the same phenomena; Glucine, in a simliar situation, was perfectly fused into a white enamel. Zircon, under the same treatment, exhibited a similar appearance.

CLXIV.

FUSION OF LIME.

When the compound flame fell upon Lime, the splendour of the light was insupportable to the naked eye; and when viewed through deep-coloured glasses, (as, indeed, all the experiments ought to be,) the Lime was seen to become rounded at the angles, and gradually so sink, till, in the course of a few seconds, only a small globular protuberance remained, and the mass of supporting Lime was also superficially fused at the base of the column, through the space of half an inch in diameter. The protuberance, as well as the contiguous portion of the Lime, was converted into a perfectly white and glistening enamel. A magnifying glass discovered a few minute pores, but not the slightest earthy appearance.

CLXV.

FUSION OF MAGNESIA.

The escape of water caused the vertex of the cone of Magnesia to fly off in repeated flakes, and the top of the frustum, that thus remained, gave nearly as powerful a reflection of light as the Lime. After a few seconds, the piece being examined by a magnifying glass, no roughness or earthy particles could be perceived on the spot, but a number of glassy smooth protuberances, whose surface was a perfectly white enamel.

Observation. Professor Silliman, of Yale College, says, that we may, perhaps, be justified in saying, in future that the primitive earths are fusible bodies, although not fusible in furnaces,—in the solar focus, nor, (with the exception of alumine and barytes,) even by a stream of oxygen gas directed upon burning charcoal.

CLXVI.

FUSION OF GUN-FLINT.

Gun-flint melted with great rapidity: it first became white, and the fusion was attended with ebullition and a separation of numerous small ignited globules, which seemed to burn away, as they rolled out of the current of flame: the product of this fusion was a beautiful splendid enamel.

CLXVII.

FUSION OF CHALCEDONY, ORIENTAL CORNELIAN, AND *Red Jasper.*

Chalcedony melted rapidly, and gave a beautiful bluish-white enamel, resembling opal.

Oriental Cornelian fused with ebullition, and produced a semi-transparent white globule, with a fine lustre.

Red Jasper, from the Grampians, was slowly fused with a sluggish effervescence: it gave a greyish-black slag, with white spots.

CLXVIII.

FUSION OF THE BERYL, AND PERUVIAN EMERALD.

Beryl melted instantly into a perfect globule, and continued in a violent ebullition, as long as the flame was applied; and when, after the globule became cold, it was heated again, the ebullition was equally renewed: the globule was a glass of a beautiful bluish-white colour.

The phenomena exhibited by the Emerald of Peru, were similar; only the globule was green, and perfectly transparent.

CLXIX.

FUSION AND COMBUSTION OF LEUCITE.

Leucite instantly fused into a perfect transparent white glass; the fusion was attended with strong ebullition, and many ignited globules darted from it, and burnt in the air, or rolled out upon the Charcoal, and then burned.

Observations. It is probable that these globules were potassium, as this stone contains more than 20 per cent of potass.

In addition to these and other interesting experiments, Mr. Hare fused porcelain, common pottery, fragments of hessian crucibles, Wedgewood's ware, various natural clays, as pipe and porcelain clay, fire-brick, common brick, and compound rocks, with equal ease.

M. Lampadius, on making use of the gas blow-pipe, found the heat, which is produced by the combustion of oxygen with carburetted hydrogen gas procured from coal, to be more intense than that with pure hydrogen

OBSERVATIONS ON THE FUSION OF SUBSTANCES BY MEANS OF BURNING GLASSES.

This mode of generating intense heat, was much better known to the ancients than it is to the moderns. Archimedes set fire to Marcellus's navy, by means of a burning-glass composed of small square mirrors, moving every way upon hinges; which, when placed in the sun's rays, directed them upon the Roman fleet, so as to reduce it to ashes at the distance of a bow-shot. The most remarkable modern burning-glasses, are those of Magine of 20 inches diameter; of Sepatala of Milan, near 42 inches diameter, and which burnt at the distance of 15 feet; of Settala, of Vilette, of Tchirnhausen, of Buffon, of Trudaine, and of Parker.

That of M. de Villette was three feet eleven inches in diameter, and its focal distance was three feet two inches. Its substance is a composition of tin, copper, and bismuth. . Some of its effects were, that a silver six-pence melted in 7½″; a King George 's halfpenny melted in 16″, and ran in 34″; tin melted in 3″, and a diamond weighing 4 grains, lost ⅜ths of its weight.

That of M. de Buffon is a polyhedron, six feet broad, and as many high, consisting of 168 small mirrors, or flat pieces of looking glass, each six inches square; by means of which, with the faint rays of the sun in the month of March, he set on fire boards of beech wood at 150 feet distance. Besides, his machine has the conveniency of burning downwards, or horizontally, each speculum being moveable, so as to be set to a proper inclination for directing the rays towards any given point; and it turns either in its greater focus, or in any nearer interval, which our common burning-glasses cannot do, their focus being fixed and determined. M. de Buffon, at another time, burnt wood at the distance of 200 feet. He also melted tin and lead at the distance of above 120 feet, and silver at 50.

Mr. Parker, of Fleet-street, London, was induced, at an expence of upwards of 700l. to manufacture a large transparent lens, capable of fusing and vitrifying such substances as resist the fires of ordinary furnaces, and more especially of applying heat in vacuo, and in other circumstances in which it cannot be applied by any other means. After directing his attention for several years to this object, and performing a great variety of experiments in the prosecution of it, he at last succeeded in the construction of a lens, of flint-glass, three feet in diameter, which, when fixed in its frame, exposes a clear surface of 32 inches; the distance of the focus is 6 feet 8 inches, and its diameter 1 inch. The rays from this large lens are received through a smaller one of 13 inches diameter, focal length 29 inches, and diameter of the focus ⅜ths of an inch. This second lens increases the power of the former more than 7 times, or as the square of 8 to the square of 3. The following table presents the most remarkable experiments performed with this double lens.

SUBSTANCES FUSED.	Weight in Grains	Time in Seconds.
Pure Gold	20	3
—— Silver	20	4
—— Copper	33	20
—— Platinum	10	3
—— Nickel	10	3
Cube of Bar Iron	10	12
——— Cast Iron	10	3
——— Steel	10	12
Scoriæ of Wrought Iron	12	2
Barytes	10	7
Topaz	2	45
Oriental Emerald	2	25
Crystal Pebble	7	6
White Agate	10	30
Oriental Flint	10	30
Rough Cornelian	10	75
Jasper	10	25
Onyx	10	20
Garnet	10	17
White Rhomboidal Spar	10	60
Zeolite	10	23
Rotten Stone	10	80
Slate	10	2
Asbestos	10	10
Lime Stone	10	55
Pummice Stone	10	24
Lava	10	7
Volcanic Clay	10	60
Cornish Moor Stone	10	60

In the experiments on iron, the lower part, *i. e.* that part in contact with the charcoal, was first melted, when that part which was exposed to the focus remained unfused: an evidence of the effect of flux on this metal.

Several of the semi-crystalline substances, exposed to the focal heat, exhibited symptoms of fusion: such as the agate, oriental flint, cornelian, and jasper. Garnet completely fused on black-lead in 120″, lost ¼th of a grain, became darker in colour, and was attracted by the magnet. Ten cut garnets taken from a bracelet, began to run, the one into the other in a few seconds, and at last formed into one globular garnet. The clay used by Mr. Wedgewood, to make his pyrometric test, ran in a few seconds into a white enamel. Seven other kinds of clay sent by Mr. Wedgewood, were all vitrified. Several experiments were performed on lime: a globule of this being put into the mouth, flew into a thousand pieces, owing to the moisture.

A small burning lens for setting on fire substances in vacuo, or enclosed in bell-glasses containing oxygen and other gases, may be seen in Plate 3.

CHAPTER V.

EXPERIMENTS ON CHEMICAL AFFINITY.

CHEMICAL Affinity is that tendency to unite, which many bodies, possessing different qualities, exert towards each other. Thus, we say that Sulphuric Acid has an affinity for Lime; and Water for Sugar, because such liquids having the power to dissolve, are thereby capable of combining chemically with the substances. Affinity urges heterogeneous particles towards each other, and, of course, is the cause of the formation of new integrant particles, composed of a certain number of heterogeneous particles. These new integrant particles afterwards unite by cohesion, and form masses of compound bodies. Thus an integrant particle of water is composed of particles of hydrogen and oxygen, urged towards each other, and kept at an insensible distance by heterogeneous affinity; and a mass of water is composed of an indefinite number of integrant particles of that fluid, urged towards each other by homogeneous affinity. Heterogeneous affinity is universal, as far as is known; that is to say, there is no body whose particles are not attracted by the particles of some other body.

It is generally believed that the chemical combination of substances is owing to the different states of electricity in which they may be when they come in contact with each other: for example, acids are in a *negative*, and alkalies in a *positive* state of electricity. Metals are in the latter state after having received a dose of oxygen for their oxidisement. If, on the contrary, acids are rendered *positive*, or alkalies *negative*, they will not unite with substances which remain in their natural states. The following experiment is here inserted, as an example of the non-affinity of some substances for each other.

CLXX.

NON-AFFINITY OF STEEL FOR WATER.

If the blade of a well polished knife or razor, be dipped in a glass of cold Water; the particles of each of these two bodies do not seem to come in contact with each other; for when the blade is taken out, the water slides off, leaving the blade quite dry, as if it had previously been smeared with any greasy substance. In the same way, if a common sewing needle be laid horizontally on a cup of water, it will not sink, but form a kind of trench on the surface, in which it lies and floats about. This proceeds from the little affinity which exists between cold water, and polished steel.

CLXXI.

SOLUTIONS NOT ATTENDED WITH CHANGE OF BULK.

In the Chemical combination of Fluids with Solids, the compound occupies no more room than the solvent did, previous to Combination.

Put some Sugar, Muriate of Soda, (Common Salt,) or any other Salt, into an ounce of water, until no more will be dissolved. The Solution will measure just an ounce, as the Water did before the addition of the Salt: but although there is no increase of *bulk*, there is a considerable increase of *density* and *specific gravity*.

CLXXII.

AFFINITY OF OILS FOR ALKALIES.

Pour into a phial half an ounce of any animal or vegetable oil, (as olive oil,) add to it the same quantity of water, and shake the Phial violently. No appearance of combination will take place, for whenever the agitation ceases, the oil will be seen to rise to the surface of the Water. Now throw in two drams of Soda, Potass, or Ammonia, and shake again. The case will now be different, for the Alkali combining with the oil, forms a soap, which is readily miscible with water, and the whole will have the appearance of thick cream.

Observations. The attachment of alkalies to acids, overcomes that towards oils: consequently the above formed soap may be decomposed by the introduction of any acid, such as the diluted sulphuric, or even common vinegar. In these cases, the alkali will leave the oil, (which will again swim on the top) and combine with the acid, with which it forms a saline solution.

CLXXIII.

AFFINITY OF ALKALIES FOR OILS,

Exemplified in the Discharge of Grease and Oil Spots from Clothes, &c.

When Grease or Oil Spots are to be removed from clothes, the part is to be rubbed over with a Solution of Soda, Potass, or Ammonia, in a little water. Either of these Alkalies will combine with the Oily matter, and form with it a Soap, which will speedily disappear by the application of a little water.

Observation. Spots of bees wax and fresh paint may be removed in the same way, by using oil of turpentine.

CLXXIV.

ETHEREAL SOLUTION OF CAUTCHOUC,

(India Rubber.)

Put some thin Slips of India rubber (cut by a scissars) into a ground stoppered phial, containing an ounce of very pure Sulphuric Ether. In two or three days the gum will be completely dissolved, and the mixture will be of a brownish yellow colour. This Solution is an excellent varnish and should be laid on with a smooth brush. An elastic tube may be formed of it by frequently brushing over a wax taper of any length with this solution: the Ether will evaporate, leaving the Gum on the mould, and possessing the same properties which it did before solution.

Observations. There is little doubt but this varnish might be brought into use to form an inner coating for the keys of flutes, by which the holes may very effectually be stopped. If brought to perfection, it would answer the purpose much better, by its elasticity, than either leather, or the alloy of metals at present in use.

CLXXV.

AFFINITY OF MERCURY FOR METALS IN GENERAL

If Mercury be poured into a wine glass, its upper surface will be convex; that is, a kind of foss or trench will be formed all round the Mercury, between it and the edges of the glass. Here no affinity exists between Mercury and glass; but if the Mercury be poured from the glass, into a Tin, Brass, or other metallic cup; the upper surface will be *concave*, from the affinity which it has for these metals; and of course from its consequent adhesion to them.

Observation. The mercury should not be long left in the metallic cup, as from its readiness to combine with almost all metals, it will soften their surfaces, and thereby become itself adulterated.

CLXXVI.

AFFINITY OF GOLD FOR MERCURY.

Immerse a rod, or other piece of Gold, in a wine glass containing Mercury: On withdrawing it, the Gold will have lost its yellow colour on the surface, by being covered by a coat of Mercury, which, from affinity for the precious metal, forms with it an alloy or amalgam. *See* Experiments 33, 34, &c.

Observations. After the performance of this experiment, the mercury should be carefully wiped off from the gold; or, what is better, the gold should be dipped in dilute nitric acid. This will combine with the mercury, but leave the gold untouched.

CLXXVII.

SOLUTION OF IRON IN CARBONATED WATER; *or* *An Extemporaneous Preparation of a Chalybeate Draught.*

Prepare a phial nearly filled with water, impregnated by Carbonic Acid Gas from Carbonate of Lime and Sulphuric Acid. Into this pour suddenly some Iron Filings; shake the phial well. A good deal of the Iron will be dissolved by the Carbonic acid, and more will remain oxidated at the bottom. If this water is drank, the pleasing taste of the Carbonic acid will be gone, but there will be a *chalybeate one in its stead;* the same as that in all waters impregnated by Iron.

Observation. What is called common *Soda Water,* will answer the above purpose equally well; but in this case, the filings must be put into the bottle *before* the carbonated water, otherwise its well-known unmanageable nature will prevent it, after bottling.

CLXXVIII.

AFFINITY OF LIME FOR CARBONIC ACID.

If, to half a wine glass of clear Lime Water, a small quantity of water impregnated with Carbonic acid be added, a white precipitate of Carbonate of Lime will immediately take place, which will render the liquid milky.

Observation. The same will happen if carbonic acid gas, from a mixture of carbonate of magnesia, or lime with sulphuric acid in a tubulated retort, be let up into a small jar of lime water over *mercury.* The cause of the milky appearance is the insolubility of the new-formed salt, viz. the carbonate of lime.

CLXXIX.

AFFINITY OF THE ACIDS FOR IRON.

Over Iron-filings, in a wine glass, pour a small quantity of either of the following acids, in a diluted state, viz. the Sulphuric, Nitric, Muriatic, or Acetic, each of which has the power of attacking the iron. During all these combinations, violent effervescence will take place, occasioned by a rapid disengagement of hydrogen gas from the water, which is decomposed by the mutual action of the metal and the acid. But when the nitric acid is used, a great deal of nitrous gas will be evolved. The ultimate products of these combinations will be either sulphate, nitrate, muriatie, or acetate, of iron, according to the acid employed. The solutions should be evaporated and crystallized; or put into phials for future use.

CLXXX.

NECESSITY OF THE PRESENCE OF WATER, TO PROMOTE *Chemical Action.*

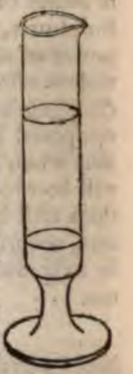
If the strongest Nitric Acid be poured on Mercury, in a wine glass, very little or no action will take place between these substances; but, if water be added, an immediate solution, attended by a most active effervescence, or salient motion of the mercury in the fluid, will take place. During this eagerness of the two bodies to unite, a variety of colour, but chiefly green, will be presented to the eye; and nitrous fumes will be disengaged in abundance. When the effervescence ceases, the metal will be dissolved, and the whole converted into a transparent liquid, like water. If a small quantity of the metal should remain undissolved, after the action ceases, a slight addition of the acid will cause the effervescence and solution to recommence. Evaporation, in a warm place, will convert this solution into Crystals known by the name of Nitrate of Mercury.

Observations. Here the water acts as a medium of solution, not only by diluting the acid, and thus enabling it to attack the metal by a large surface; but also, by its own decomposition, affording oxygen to the metal, which by some means, it must have, before it can be acted on by the nitric acid.

When metallic oxides are acted on by the acids, they require water only to *dilute* the acid; or in other words, to give it a larger surface; but metals themselves must be first oxidised by decomposition of the water, before they can be acted on or dissolved by acids. Concentrated acids, in general, poured over metals, are almost as inert as so much oil.

CLXXXI.

Two Bodies PREVENTED FROM ACTING ON EACH OTHER *By the Intervention of a Third Body.*



Pour into a tall glass, a dram of carbonate of potass, dissolved in an ounce of water: introduce, by means of the dropping tube under this, a dram of muriate of soda dissolved in half an ounce of water. This last-mentioned solution, from its specific gravity, will remain underneath. Introduce now by the same tube, half an ounce of sulphuric acid, diluted by half an ounce of water: this, from its still greater specific gravity, will remain beneath both the others. The three layers of fluids will now remain at rest; for the muriatic acid of the muriate of soda being perfectly saturated by the soda, and having less affinity for the potass than for it, the two fluids, containing carbonate of potass and muriate of soda, exert no action upon each other. In the same way, the sulphuric acid has not the power of separating the soda from the muriatic acid, as these two last substances have a superior affinity for each other than soda has for sulphuric acid. On the other hand, the sulphuric acid is prevented by the solution of muriate of soda, from exerting any influence on the carbonate of potass. In this quiescent state, then, they will remain until the whole is agitated, when the sulphuric acid will seize on the potass, driving off the carbonic acid with great effervescence.

Observation. In using the dropping tube, as above directed (see plate 3) the fluid must be first poured in, and the fore finger placed on the top, so as to close the aperture completely, whilst the tube is held between the thumb and middle finger. Now immerse the tube in the fluid in the glass, and when the capillary point is at the bottom, withdraw the fore finger, so that the air may press on the fluid in the tube. The consequence will be, that the tube will be emptied in a few seconds, without disturbing that in the glass, further than raising it gently above itself.

CLXXXII.

THE SOLUTION OF BODIES IN ACIDS INTERCEPTED BY *Mechanical Pressure.*

Put into a Florence-flask some powdered Carbonate of Lime, (Chalk), and pour over it some diluted Sulphuric, Muriatic, or Nitric Acid; immediate effervescence will be the consequence. Now stop the mouth of the flask with a cork; the effervescence will instantly stop, upon the same principle, that fluids refuse to boil, when the superincumbent pressure is to a certain extent greater than usual. If the cork be withdrawn, the effervescence will be resumed.

Observations. The agitated motion of bodies undergoing solution, does not differ from ebullition; for, in both cases, the fluids vaporize; and when this pressure is used, the ascension of vapour must stop, not having sufficient mechanical force to overcome the power of the body which presses upon it.

This experiment may be varied, by pouring nitric acid over mercury in a wine-glass, and by placing the palm of the hand closely over it, when the effervescence is going on. The same phenomena will take place.—Care must be taken, however, to wipe the edges of the glass, in case any of the acid may have fallen upon it; as it will leave a stain upon, and perhaps may burn the hand.

CLXXXIII.

SOLUTION OF TIN IN NITROUS ACID.

Pour half an ounce of Nitrous Acid over half an ounce of granulated Tin (Pulvis Stanni) in a tumbler: very little action will take place, owing to the inability of both substances to present to each other a sufficient surface. But if an ounce of water be added, a very violent commotion will ensue, during which, the Tin, in an oxidated state, and of a yellow colour, will be seen to run up and down from the bottom to the surface, whilst a great quantity of Nitrous Gas is disengaged. This Solution is the Nitrite of Tin.

CLXXXIV.

PREPARATION OF MURIATE OF TIN.

Put an ounce of granulated Tin into a Florence-flask, and pour over it two ounces of pure Muriatic Acid. Place the Retort over a lamp, and apply heat until the solution is complete: this solution will be colourless, and should be preserved in a well stopped phial, and in a dark place.

Observation. The above solutions of Tin, as will be seen hereafter, are much used by dyers.

CLXXXV.

ACTION OF NITRIC ACID ON COPPER.

Put two drams of Copper filings, or turnings, into a wine-glass, and pour over them four drams of Nitric Acid, diluted with two or three drams of water. A violent action will immediately commence, and continue until the whole of the Copper is dissolved. The resulting compound, which is a solution of Nitrate of Copper, will be of a colour between green and blue. This solution may be immediately crystallized by evaporation; or preserved in a vessel for use.

CLXXXVI.

ACTION OF NITRIC ACID ON COPPER;

As exemplified in the art of Etching uponCopper-plates.

Warm a plate of Copper, and rub it over on both sides with bees-wax; or immerse the plate in a sufficient quantity of the melted wax. If the surface be uneven, warm it gently at the fire, in order that the wax may run quite level.

When cold, etch upon one side of the plate, with a common stocking needle, or steel point, any design, writing, landscape, or other subject; taking care that all the lines or marks are cleanly made through the wax to the surface of the copper. When the design is prepared, lay the plate flat, with the etching upwards, in a place where it may not be disturbed, and then smear the upper surface over with a feather dipped in Nitric Acid: leave it in this state, until the copper has been sufficiently acted on; this may be known, by washing it over with cold water, which dissolves the Nitrate of Copper: if the marks are not sufficiently deep, lay on more acid. After the design has been completely formed, dip the plate in hot water; this will melt off the wax.

Observations. Bees wax, (for the sake of simplicity, in a mere experiment) is directed for use here, but a composition of wax, asphaltum, black-pitch, and Burgundy-pitch, is employed by artists. They, also, blacken the surface of the coating by the smoke of a candle, in order that the marks of the needle may be better known.

CLXXXVII.

ACTION OF THE NITRIC AND MURIATIC ACIDS ON GOLD.

If pure Gold is immersed in Nitric Acid in any degree of concentration, it will not be acted on. Neither will solution take place when this metal is exposed to Muriatic Acid. But if a dram of Nitric Acid, and four drams of Muriatic Acid be poured over a seven-shilling-piece: or rather over a piece of pure Gold of that weight, a violent action will immediately be set up, accompanied by a copious evolution of Nitrous Gas. This solution, which is the Nitro-Muriate of Gold, and of a yellow colour, should be kept for further use.

This Experiment may be varied, by dropping into the Compound Solvent as much Gold Leaf as it will dissolve. For this purpose, Gold Leaf, being made of the purest Gold, is a much better substance than guinea or jeweller's Gold; as these substances (being alloys of Gold with other metals) would afford an adulterated solution of Gold improper for experiment. One hundred grains of gold require for their solution two hundred and forty-six of this mixture.

If the pure solution be set aside, it will soon be transformed into very beautiful small crystals of a deep yellow colour.

Observations. The combination of acids above-prescribed is what has been usually termed aqua regia, from its power of dissolving gold, which resists the action of every other menstruum. The phenomena of the solution of gold in nitro-muriatic acid have been accounted for in many ways. The following opinions are offered to the reader's consideration.

Is it not probable, that what is called nitro-muriatic acid is merely diluted chlorine? That the reason that this substance has the power of dissolving gold, is, that the nitric acid gives up an excess of oxygen to combine with an excess of hydrogen in the muriatic acid, to form water? And that thus three substances are formed, viz. nitrous acid, chloric acid, and water. If we adopt the term hydrochloric acid for muriatic acid, because that substance is known to consist of hydrogen and chloric acid, the question will be set in a clearer light. When gold, then, is dissolved by the union of the nitric and hydrochloric acids, instead of that metal being previously oxidised by the nitric acid, before solution in the hydrochloric; may we not suppose that the nitric acid merely rids the hydrocloric of its hydrogen, and converts it into chloric acid which has the power of itself, without any other assistance, of dissolving gold; and that what is called nitro-muriate of gold, is mere chlorate of gold? When gold is revived from the nitro-muriate, or rather chlorate, by exposure to hydrogen gas, or sulphurous acid gas, is it not probable that the very combination of this substance with chlorine, in a moist state, converts it into hydrochloric, which, being unable to hold the metal in solution, precipitates it?

CLXXXVIII.

NITRO-MURIATIC SOLUTION OF PLATINUM.

Proceed, in all respects, as in the last Experiment; except in using small portions of Platinum instead of Gold; and, as a solvent, use the following proportions of the acids, viz. half an ounce of Nitric acid, and one and a half ounce of Muriatic acid. The solution will be Nitro-muriate of Platinum.

Observation. In a similar way, palladium may be dissolved in the nitro-muriatic acid: the product being of a beautiful scarlet colour.

CLXXXIX.

SOLUTION OF GOLD IN CHLORINE.

Immerse Gold-leaves in liquid Chlorine; they will immediately disappear, being dissolved. Continue to supply leaves as long as they disappear. This is the Chloride of Gold, and is very similar, in every respect, to what is termed Nitro-muriate of Gold.

CXC.

TWO METALS IN CONTACT,

Acted on with more Energy by an Acid, than one Metal.

Pour some diluted Muriatic Acid into a Wine Glass immerse an Iron rod, only a slight action will take place; but if the end of a Silver spoon be made to touch the Iron under the liquid, a Galvanic circle will be formed, and the Acid will be decomposed with great rapidity, giving out Hydrogen Gas, not only where it is in contact with the Iron, but also where in contact with the Silver spoon.

CXCI.

UNION OF HYDROGEN GAS WITH CHLORINE GAS.

Provide a Jar with a narrow neck, and ground stopper, (See apparatus for Gases), place it on the shelf of a Mercurial trough. Now pass up into it, as nearly as can be guessed, equal volumes of Chlorine and Hydrogen Gases. Tie a piece of bladder over the neck, and let it stand for a day or two; then take off the bladder, and immerse the neck of the Jar under water. Take out the stopper in that situation; the water will immediately rush up and fill the Jar. This vacuum is accounted for by the union of the Gases, in forming Muriatic Acid Gas, or Hydrochloric Gas, which will be rapidly absorbed by the water.

CXCII.

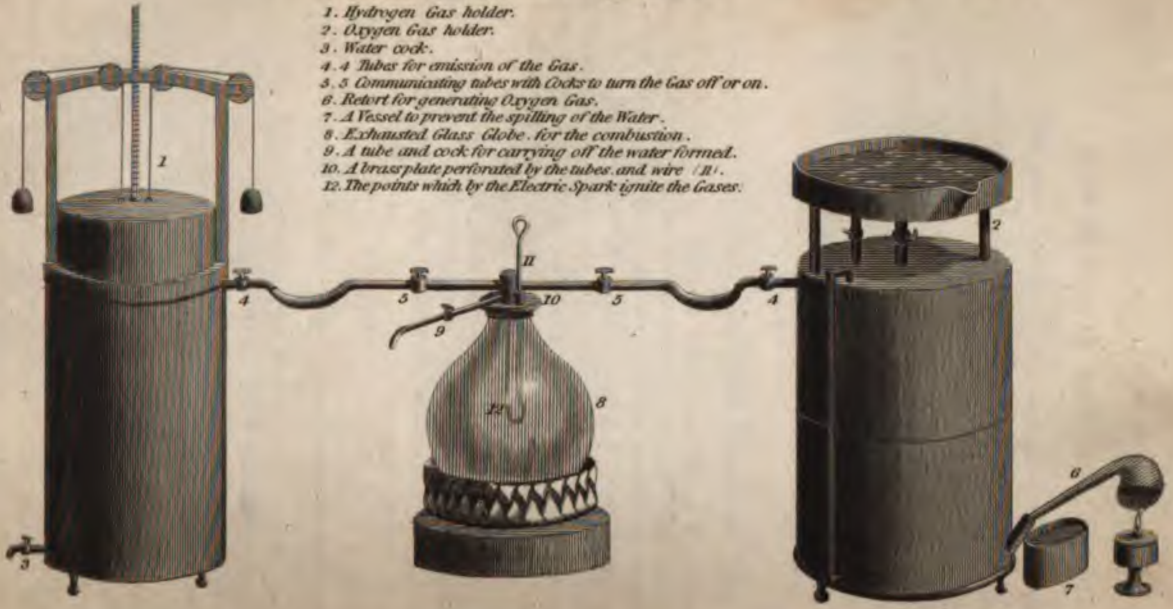
COMBINATTION OF NITROUS GAS AND ATMOSPHERIC AIR.

If Nitrous Gas be passed into a Jar, (one third filled with Atmospheric Air,) over Mercury in the Pneumatic trough; the compound of the two Gases will be Nitrous Acid, which is of a reddish brown colour. Here both the Oxygen and Nitrogen Gases, of which the Atmosphere is composed, combine with the Nitrous Gas. If previously to the mixture of the Gases, a piece of Litmus paper be moistened, and attached to the inside of the Jar, it will be reddened as soon as the Nitrous Acid is formed.

PLATE X.

Apparatus for the formation of Water, by the combustion of Hydrogen with Oxygen Gas.

1. Hydrogen Gas holder.
2. Oxygen Gas holder.
3. Water cock.
4. 4 Tubes for emission of the Gas.
5. 5 Communicating tubes with Cocks to turn the Gas off or on.
6. Retort for generating Oxygen Gas.
7. A Vessel to prevent the spilling of the Water.
8. Exhausted Glass Globe. for the combustion.
9. A tube and cock for carrying off the water formed.
10. A brassplate perforated by the tubes. and wire (11).
12. The points which by the Electric Spark ignite the Gases.



CXCIII.

VARIATION OF THIS EFFECT,

as a Test for Nitrous Gas.

Lift suddenly a Jar containing Nitrous Gas, from the Pneumatic shelf, and present its open end to the Atmosphere, by holding it in an inclined position. The Gas which was formerly transparent and invisible, will now be converted (by combination with the air) into Nitrous Acid Gas, which will fill the Jar with reddish dense fumes.

CXCIV.

WATER PRODUCED BY THE COMBINATION

of Hydrogen and Oxygen Gases.

Charge two vessels, (See Plate 10.) one with Oxygen and the other with Hydrogen Gas; and let communicating tubes from each meet at the opposite sides of an *exhausted* glass Globe. When the cocks are turned and the Gases begin to rush in, they must be fired by the electric spark. A most beautiful combustion will be kept up, and a continual formation of Water will be the consequence of it, as long as the Gases are supplied. The water as it is formed will be seen to trickle down the sides of the Globe; and its weight, when the experiment is at an end, will be found to be equal to that of the two Gases before combustion.

Observations. Two or three handfulls of pure Lime should be thrown into the hydrogen gas-holder to free it from any accidental carbonic acid. Also, a small quantity of muriate of lime should be scattered throughout the tubes which lead to the globe, to free the gases from moisture. The proportions of these gases, required for the formation of every 100 grains of water, are 85 grains, in weight, of oxygen, and 15 of hydrogen gas. About 3 pints of water, is the greatest quantity ever obtained in this way. On this occasion, there were expended about 360 gallons of hydrogen and 200 of oxygen gas. It is said that a French chemist has produced water from oxygen and hydrogen gases, merely by compression.

CXCV.

METALS INCREASED IN WEIGHT

by Combination with Oxygen.

Weigh a dram of very slender Iron wire; roll it up in a coil, and deposit it in the bowl of a common tobacco pipe. Place the bowl between the bars of a grate in which there is a clear fire, and heat it red hot. Whilst the wire is heating, attach a bladder containing Oxygen Gas to the mouth-end of the pipe, so that it shall be perfectly air-tight. Now press the bladder, so that the Gas may escape into the bowl over the red hot Iron wire. The Iron will burn like any other combustible, and will combine with the Oxygen, being thus transformed into an Oxide of Iron. In a cold state this combination would not take place, as it is only at a red heat they have such affinity for each other. If the bowl has been kept free from dust, and the Oxide weighed, it will be found to be one dram and twenty grains instead of the one dram as originally employed. Whence this accession of weight? Twenty grains of Oxygen have combined with the dram of Iron.

Observations. The bladder should be filled from a jar, and the neck tied low down, so that the end of the pipe may enter at the top and be fastened a little above. When this is done, the lower fastening is to be taken off. The pipe should be proved to be clean by blowing through it.

XCVI.

COMBINATION OF SULPHUR WITH POTASS.

Rub together very smartly in a mortar, one ounce of Sulphur with the same quantity of Potass. When properly combined, the colour will be dark green, Sulphuret of Potass being formed. This substance should be kept in a well stopped phial, as it is very liable to abstract moisture from the Atmosphere, by which Sulphuretted Hydrogen is formed :—a Gas of a most fetid and disagreeable odour.

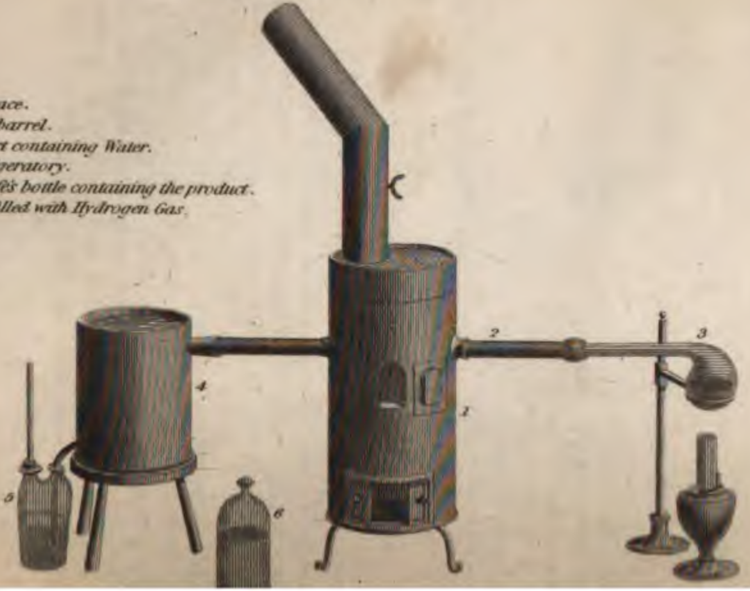
CXCVII.

ANOTHER MODE OF COMBINATION.

Put into a Crucible, an ounce and a half of Sulphur, with two ounces of dry Carbonate of Potass. Cover the Crucible either by a lid, or with clay, so that there shall be a small aperture for the escape of the Carbonic Acid Gas, which will quit the Alkali when heated. The aperture is to be shut, whenever a slip of paper dipped in Lime water, and held over it, ceases to be encrusted with Carbonate of Lime; this being a proof that all the Carbonic Acid has been expelled. Let the whole now have a dull red heat, and then pour it out while fused, on a marble slab. When

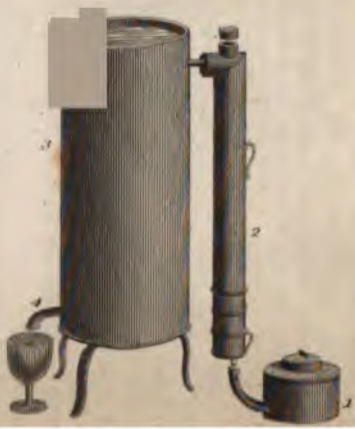
Apparatus forproducing Hydrogen Gas, and Sulphuret of Carbon.

1 Furnace.
2 Gun barrel.
3 Retort containing Water.
4 Refrigeratory.
5 Woolfe's bottle containing the product.
6 Jar filled with Hydrogen Gas.



Apparatus forthe preparation of Water, by Combustion of Alcohol.

1. Alcohol Lamp.
2. Tube for ascension of the steam produced by the combustion.
3. Refrigeratory.
4. The Product. Water.



sufficiently cool to handle, enclose it in a dry well stopped phial.

Observations. To prepare Sulphuret of Soda, proceed in all respects with the same quantities of sulphur and soda as of sulphur and potass, in the last experiment. These substances have been termed Hepars, Hepatic sulphurs, &c. because in colour, they resemble the liver.

CXCVIII.

Combination of Sulphur with Iodine.

Put a small quantity of Iodine, with the same quantity of Sulphur into a phial, and hold it over a candle; these substances will speedily combine, forming Sulphuret of Iodine, which is of a black colour and striated structure.

CXCIX.

Combination of Sulphur with Chlorine.

Forming Thomson's Fuming Liquor.

Heat a few grains of Sulphur in a jar of Chlorine Gas. The Chlorine will be absorbed, and the result of the combination will be a volatile fluid, of a red colour by reflected light, but a yellowish green by transmitted light. The vapour of this liquid is so pungent, as to cause, at any time, the eyes to overflow with tears.

CC.

Preparation of Sulphuret of Carbon

An earthen tube, coated with clay, is to be passed through a furnace, similar to that used for producing Hydrogen Gas. (Plate 11.) Into the tube are to be put several pieces of newly made Charcoal, arranged so as not to choke it up. To one end of the tube must be attached a bent glass tube fixed in a two-necked Woolfe's bottle, partly filled with water. In the other neck of the bottle is to be inserted a safety tube. Let the beak of a small retort containing Sulphur, be luted to the other end of the earthen tube; and underneath the retort, place a lamp. Now set fire to the fuel in the furnace, and when the tube is red hot, kindle also the lamp under the retort. When converted into vapour, the Sulphur will combine with the Carbon, and both will pass together through the tube to be condensed by the water. This

Compound being heavier than Water, will sink in it, and it may be distinguished from the Water by a slight milky appearance. When no more Gas passes into the bottle, detach the apparatus, and pour what has been obtained into a retort, containing dry Muriate of Lime, and distil by a gentle sand heat, not exceeding 112°. By this distillation pure Sulphuret of Carbon is obtained.

Observations. This is that substance, which in another part of this volume has been proved to produce, by evaporation, the most intense cold. On account of its great volatility, it should be preserved in a well stopped phial.

CCI.

AFFINITY OF SULPHUR FOR IRON.

Put a bar of Iron into a furnace, or smith's forge, and give it a white heat. Take it out quickly, and rub it with roll brimstone, (Sulphur) holding it over a bason. The Sulphur and Iron will combine and fall down in drops. Rub the Iron thus, as long as drops fall down. These drops are Sulphuret of Iron, and when congealed, they are to be preserved in a well-stopped phial.

CCII.

TO PREPARE GREY SULPHURET OF IRON.

Melt together in a crucible 3 ounces of Iron with 1 ounce and 6 drams of Sulphur. The Compound will be of a grey colour, devoid of lustre, but magnetic.

Observations. There is also a phosphuret of iron, of nearly the same colour, but possessing lustre. This kind of cast Iron is what is termed *cold short*, and must be purified before it can be used for purposes where tenacity is an object.

CCIII.

PREPARATION OF SULPHURET OF SILVER.

Put a Crucible containing Sulphur upon the fire, and when vapour arises from it, hold over it, (by means of an Iron tongs or forceps,) a piece of Silver: the Silver will be quickly blackened, or encrusted with a coat of Sulphuret of Silver.

Observation. This is the mode imputed to the Hebrew tribes, for making the silver coin of these realms less troublesome to carry. The crust or sulphuret when in considerable quantity, is afterwards exposed to a strong heat; whereby the sulphur is driven off, and the silver is revived. This piece of Jewish ingenuity is only discoverable by the loss of weight in the coin, as the impressions are as marked as ever;—the sulphuret being struck off quite clean by a smart blow of a hammer upon an anvil.

CCIV.

TO PREPARE SULPHURET OF ARSENIC.

(Used in Painting.)

Put half an ounce of Arsenic with half an ounce of Sulphur into a well covered crucible, and submit them to a good heat: they will soon melt, forming Sulphuret of Arsenic, which is a most beautiful red Crystalline substance used as a pigment.

CCV.

AFFINITY OF SULPHUR FOR MERCURY.

When two drams of Sulphur and one of Mercury are rubbed together in a mortar, the yellow colour of the one, and the lustre of the other will disappear; the whole being converted into a black powder, which is the Black Sulphuret of Mercury. If this powder be put into an Alembic, and a great heat be applied, the whole will sublime into the Capsule, and there appear in a beautiful red mass, known by the name of Vermilion. It must now be powdered, to appear like that known in Commerce as *Native Vermillion.*

CCVI.

AFFINITY OF IODINE FOR POTASS.

Prepare in a Wine Glass, a Solution of very pure Potass, and add as much Iodine to it as will continue to precipitate Crystals of Iodate of Potass. Pour off the liquid and wash the crystals, by pouring over them a dram of strong Alcohol. Preserve them in a phial for use.

CCVII.

AFFINITY OF IODINE FOR AMMONIA.

Prepare a Jar of Ammoniacal Gas, and immerse in it a small portion of Iodine. The Gas will be absorbed by this substance, forming a compound, which is sometimes of a brown colour, sometimes dark red, and at others, possessing a metallic lustre. These characteristics depend entirely on the quantity of Gas absorbed

CCVIII.

UNION OF IODINE WITH MERCURY.

If a dram of Mercury be put into a wine glass, and half a dram of Iodine be placed over it, a very speedy union will take place, accompanied by much heat The compound which is Iodide of Mercury, will be of a most beautiful Scarlet colour; and may be used as a pigment.

CCIX.

COMBINATION OF IODINE WITH PHOSPHORUS.

Put into a small phial, or glass tube, a small piece of Phosphorus and a like quantity of Iodine: these two substances will combine with extrication of heat (and sometimes light,) forming Iodide of Phosphorus, which is a substance of a light brown colour. If this compound be put into a retort with a very small quantity of water, Hydriodic acid will come over, and may be received over Mercury.

CCX.

TO PREPARE CHLORIODIC ACID.

Prepare a jar of Chlorine Gas, and immerse in it about ten or twelve grains of Iodine. The Gas will be absorbed by the Iodine which will now be changed to a beautiful yellow colour: this is Chloriodic Acid, a solid substance, which is to be preserved in a dry phial. If to a solution of Chlorine in water, some Iodine be added, liquid Chloriodic acid will be obtained, this liquid will be of a very deep orange colour.

CXI.

AFFINITY OF PHOSPHORUS FOR LIME.

Coat with common clay, a quarter of an inch thick, a glass tube, closed at one end, twelve or fourteen inches long, and about half an inch wide; with a knife, cut off the coating for about an inch, upwards, at the closed end, and put into the tube two drams of Phosphorus cut small. The pieces will remain at the bottom, and may be seen from without. Now fill the tube as far as half an inch from the top, with newly calcined Lime, broken into pieces of the size of swan shot; and place a paper stopper rather loosely in the mouth of the tube, to prevent the access of air as much as possible. Now lay the coated part of the tube in a pan of red hot charcoal, or on a portable furnace, in such a manner, that the uncoated end may remain out of the fire, and rather lower than the other extremity. When the Lime becomes red hot, apply a lamp to the Phosphorus end. This heat will sublime the Phosphorus among the Lime, with which, in an ignited state, it will unite, forming Phosphuret of Lime, a brown substance. When no more Phosphorus remains, take the tube from the fire, and let it cool gradually, so as to prevent the glass from being broken. Preserve the Phosphuret in a well stopped dry phial.

CHAPTER VI.

EXPERIMENTS ON ELECTIVE AFFINITY.

ELECTIVE Affinity is that which is exerted between two substances to the exclusion of a third. It is often the case, that when two substances are united, communication with a third will destroy the connexion or affinity which existed between them: and instead of this alliance, another will be formed, between the new agent, and that part of the former compound, for which it had the greatest affinity. The meaning of elective affinity, then, is, that the third body, has the power of making an election, according to its nature, of whatever body it shall unite itself with from the first and second. If the second be chosen, the first shall be excluded; or if the first be chosen, the second shall be excluded.

CCXII.

GREATER AFFINITY OF POTASS AND SODA FOR ACIDS THAN FOR OILS.

Dissolve half an ounce of common soap in a tea-cup with a little warm water; when it is quite clear decant it into a wine glass, and pour into it 10 drops of Sulphuric or Muriatic Acid. The tallow of the soap will be precipitated, and being lighter than the water will swim on its surface. This precipitation is owing to the greater affinity which the Alkali has for any acid than for fat or resin.

Observations. In this way, tallow is precipitated on the surface of water (from the New-river and Thames for example) in a wash-hand bason, from the quantity of acid held in solution, in combination with earths, &c.

CCXIII.

ORDER OF AFFINITY OF SOME OF THE ACIDS FOR POTASS.

Acetic greater than Carbonic.

Put some Carbonate of Potass into a tumbler, and pour over it diluted Acetic Acid; (common distilled vinegar; which must previously be proved, by Barytes, to contain no Sulphuric Acid.) This Acid will dissolve the Potass and expel the Carbonic Acid with effervescence. The newly formed compound will be Acetate of Potass.

CCXIV.

MURIATIC GREATER THAN ACETIC.

Into the newly formed solution of Acetate of Potass, pour some Muriatic Acid as long as an Acetic smell arises from the tumbler: this smell will be occasioned by the expulsion and evolution of the Acetic Acid. The new compound will be Muriate of Potass. This salt will crystallize in cubes, and is slightly deliquescent.

CCXV.

NITRIC GREATER THAN MURIATIC.

Into the solution of Muriate of Potass obtained in the last experiment, pour some Nitric Acid; this will expel the Muriatic Acid; and a quantity of Nitrate of Potass will be held in solution. This salt may be crystallized; but the crystals are rather irregular, presenting a variety of forms.

CCXVI.

SULPHURIC GREATER THAN NITRIC.

Into the solution of Nitrate of Potass obtained in the last experiment, pour some Sulphuric Acid; a solution of Sulphate of Potass will now be formed. This salt may be crystallised in six sided prisms having pyramidal tops.

Observations. The order of affinity of potass for the different acids, is proved by the foregoing experiments to be as follows: carbonic acid; acetic acid; muriatic acid; nitric acid; and sulphuric acid. For the last of these it has greater affinity than for any of the others; and for the first less than for any that follow. If these experiments are assisted by heat the result will be more satisfactory, as the different acids discharged may be received from a tubulated retort into a receiver, and then proved by tests.

CCXVII.

ORDER OF AFFINITY OF SULPHURIC, MURIATIC, AND *Carbonic Acids for Lime.*

Put some powdered Carbonate of Lime (chalk) into a tubulated retort with water, and pour some Muriatic Acid over it. After the expulsion of common air, immerse the beak of the retort under a glass, containing Ammoniacal gas placed over Mercury: a gas will ascend, which may be proved to be Carbonic Acid Gas, by its union with the Ammoniacal Gas; both forming a solid salt, the Carbonate of Ammonia. The compound in the retort will be Muriate of Lime. If when all the Carbonic Acid Gas is driven off, Sulphuric Acid be poured into the retort, and its beak be immersed under another jar containing Ammoniacal Gas, Muriatic Acid Gas will ascend in the jar, and combine with the Ammonia, forming also a solid salt called Muriate of Ammonia, a substance destitute of smell, although both the articles used in its formation possess separately a most pungent odour. The salt now left in the retort will be an insoluble one, namely, the Sulphate of Lime: whereas, the former one, the Muriate of Lime, is one of the most soluble salts; and the one before that, the Carbonate of Lime, is only partly soluble.

CCXVIII.

ACTION OF FLUORIC ACID ON CARBONATE OF AMMONIA

Into a leaden bottle, containing diluted Fluoric Acid, put some Carbonate of Ammonia until effervescence ceases, in consequence of the escape of all the Carbonic Acid Gas. The Fluoric Acid, in combining with the Alkali, will form Fluate of Ammonia; which Salt is an excellent test for Lime in solution.

CCXIX.

AFFINITY OF FLUORIC ACID FOR SILICA; EXEMPLIFIED *in the art of etching upon Glass.*

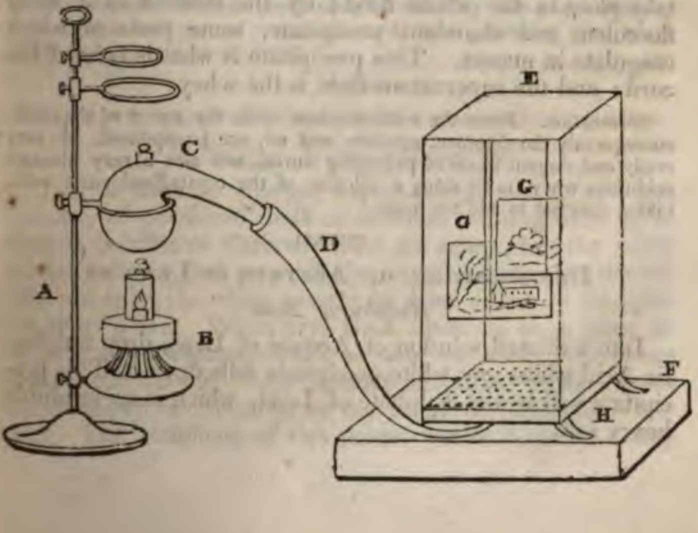
Procure several thick clear pieces of crown-glass, and immerse them in melted wax, so that each may receive a complete coating. When perfectly cold draw on them with a fine steel point, flowers, trees, houses, portraits, &c. Whatever parts of the drawing are intended to be corroded by the Acid, should be perfectly free from the least particle of wax. When all these drawings are finished, the pieces of glass must be immersed one by one in a square leaden box or receiver, where they are to be submitted to the action of Fluoric Acid, or Fluoric Acid Gas.

It will be necessary to have some water in the receiver for the absorption of the superabundant Gas; and the receiver should have a short leaden pipe attached to it for the reception of the beak of the retort. This should be well luted with wax. At the top of the receiver there is a sliding door for the admission of the plates; this is to be well luted whilst the Gas is acting. When the glasses are sufficiently corroded, they are to be taken out; and the wax is to be removed by first dipping them in warm, and then in hot water. Various colours may now be applied to the corroded parts of the glass, whereby a very fine painting may be executed. In the same manner, sentences and initials of names may be etched on wine-glasses, tumblers, &c.

Observations. Glass may also be etched, by immersing it in liquid fluoric acid, after having been coated with wax and drawn on as in this last experiment. There is this difference, however, in the use of the liquid and the gas, that the former renders the etching *transparent*, whilst that produced by the gas is quite *opaque*.

In this experiment the potass of the glass is set free, whilst the silex or sand is acted on; consequently no vessel of glass can ever be employed with safety to contain this acid in a liquid state, as it would soon be corroded into holes. It is therefore generally preserved in *leaden* bottles, on which it has no power to act. The first attempt to engrave on glass by means of fluoric acid, was made on May 18, 1787, at Thoulouse, by M. de Puymaurin.

The following is a figure and description of the necessary apparatus.



A, The lamp stand.

B, The argands lamp, having a feeble flame.

C, The leaden retort.

D, A leaden lengthening tube inserted in the bottom of the leaden box or receiver.

E, The leaden receiver where the unwaxed parts of the glass are corroded.

F, A stand for supporting the receiver.

G, G, Two pieces of glass hung within the receiver.

H, A double bottom, in the lower one the tube from the retort is inserted:—the upper one is perforated with holes for the greater transfusion of the gas through the receiver.

CCXX.

SIMPLE METHOD OF ETCHING GLASS; AS APPLIED *To Thermometers, &c.*

Coat the glass to be graduated, &c., with yellow wax, and trace with a steel point whatever is intended to be etched. Now dip the glass in Sulphuric Acid, and shake over it some fine pulverised Fluate of Lime (Fluor Spar). This salt will be decomposed by the affinity of Lime for Sulphuric Acid. Accordingly, the Fluoric Acid will be set free to attack the Silica of the Glass. Corrosion of those parts which are uncovered by the wax, will be the consequence.

CCXXI.

DECOMPOSITION OF MILK BY ACIDS.

To a pint of new Milk, in a glass goblet, add half a dram of diluted Sulphuric Acid: an immediate change will take place in the whole fluid; by the descent of a white flocculent and abundant precipitate, some parts of which coagulate in masses. This precipitate is what is termed the curd; and the supernatant fluid is the whey.

Observation. Here the acid combines with the water of the milk, consequently the albumen, gelatine, and oil, are precipitated. A very ready and elegant mode of procuring curds, and also a very pleasant acidulous whey, is by using a solution of the crystallised citric acid; taking care not to add too much.

CCXXII.

DECOMPOSITION OF ACETATE OF LEAD BY *Sulphuric Acid.*

Into a diluted solution of Acetate of Lead, drop Sulphuric Acid whilst any white precipitate falls down. This precipitate will be the Sulphate of Lead, which is an insoluble heavy salt.

Observations. Here the acetic acid quits the metal, which may be proved by performing the experiment in a tubulated retort, and collecting the pure acetic acid in a cool receiver. It will be easily known by its very pungent odour. On this principle, a drop of sulphuric acid is a good test for the smallest quantity of lead in any transparent liquid. The acetate of lead, on the other hand, is a good test for the presence of sulphuric acid in vinegar, with which the latter is commonly adulterated.

CCXXIII.

PREPARATION OF ACETIC ACID.

Put four ounces of Acetate of Lead, in powder, into a tubulated glass retort, and pour over it four ounces of Sulphuric Acid. Place the retort in a sand-bath, the heat of which should be kept as uniform as possible. Adapt a common receiver, over which there must be constantly kept a piece of wet flannel or cotton for the condensation of the gas as it comes over. Sometimes Sulphurous Acid gas will be found to adulterate the Acetic Acid: this is easily known by the suffocating odour which it emits. The best way to prevent this, is by a slow distillation; or the whole may be distilled a second time. The Acetic Acid possesses a very pungent odour, owing to its volatility; consequently it should be kept in a well stopped phial.

Observations. In the formation of this acid, the sulphuric acid seizes on the lead; forming with it sulphate of lead; whilst the acetic acid assisted by heat is driven off to the receiver, and thence of course condensed by the abstraction of that heat.

Acetate of potass; acetate of soda, and acetate of copper, have all been used for the production of this acid. But a French chemist says that he has obtained excellent acetic acid, by distilling two pints of white wine vinegar with one of sulphuric acid, and bringing the whole suddenly to a state of ebullition.

CCXXIV.

CHEAP AROMATIC VINEGAR FOR PURIFYING LARGE *Buildings, Manufactories, &c.*

Take of common Vinegar any quantity, mix a sufficient quantity of powdered chalk or common whiting with it, as long as bubbles of Carbonic Acid gas arise. Let the white matter subside, and pour off the insipid supernatant liquor; afterwards let the white powder be dried either in the open air, or by a fire. When dry, pour upon it, in a glass or stone vessel, Sulphuric Acid as long as white acid fumes continue to ascend. This product is similar to the Acetic Acid known in the shops by the name of Aromatic Vinegar. The simplicity of this process points it out as a very useful and commodious one for purifying prisons, hospital ships, and houses, where contagion is presumed or suspected, the white acid fumes diffusing themselves quickly around.

CCXXV.

DECOMPOSITION OF NITRATE OF SILVER BY *Sulphuric Acid.*

Make a solution of six or eight grains of Nitrate of Silver in half a wine glass of water, and add to it two drops of Sulphuric Acid. A flocculent white precipitate will immediately take place, which is the Sulphate of Silver: for here the Sulphuric Acid, having driven off the Nitric Acid, forms with the Silver an insoluble metallic Salt.

Observations. To obtain precipitates, especially where they are to be preserved, the whole of a liquid operated on must be placed on a filter, which is generally a ribbed glass funnel (see annexed figure) over which is placed a piece of linen, muslin, or blotting-paper, according to the substance which is under examination. The precipitate will remain on the filter whilst the liquid runs through.

CCXXVI.

PREPARATION OF PRUSSIC ACID.

Put into a retort 2 ounces of Prussiate of Mercury, with two ounces of Muriatic Acid and ten ounces of Water. Distil over (by a gentle heat) eight ounces. Put this product again into a retort with a small quantity of chalk, and draw off, by distillation by a gentle heat, six ounces. This is ordinarily called Prussic Acid; but it is really a solution of Prussic Acid in Water.

Observations. This acid is also obtained by other processes, viz. from the blood of animals, &c. Its constituents are carbon, hydrogen, and nitrogen. It contains no oxygen, and, perhaps, this is the reason that it does not redden vegetable blues. In this respect it is analagous to chlorine, and hydrochloric acid. It smells like bitter almonds and is highly poisonous to animals.

CXXVII.

PRECIPITATION OF MURIATE OF SILVER FROM *The Nitrate, by Muriatic Acid.*

To a solution of Nitrate of Silver in water, add as much Muriatic Acid as will cause a white precipitate to fall down to the bottom of the glass. This is the Muriate of Silver, and may be freed from the water, &c., by filtration. It should be preserved in a phial in a dark place, as Light has the effect of turning it black.

Observations. In this experiment, the greater affinity of muriatic acid than nitric acid for silver is displayed: hence it is a good test for the discovery of that metal in solution: and on the other hand this salt is a good test for muriatic acid.

CCXXVIII.

DECOMPOSITION OF WRITING INK BY THE NITRIC AND *Muriatic Acids.*

Pour a solution of either of these Acids, into any quantity of writing Ink: an immediate decomposition will take place, and the Ink will lose its colour, becoming quite *transparent.*

Observation. In this experiment, the gallic acid of the gallate of iron (ink) is separated, whilst one of the other acids unites with the oxide of iron. In this way ink stains may be effaced from linen or paper; but for obvious reasons care must be taken to use the acid in a *diluted* state. Writings dipped in either of those acids in a diluted state, will be rendered invisible.

CCXXIX.

PRECIPITATION of SULPHUR FROM HYDRO-SULPHURETTED *Water, by Nitric and other Acids*

Pour a few drops of Nitric Acid into a wine-glass containing Harrowgate water: a yellow powder will be seen to pervade the fluid: this is the Sulphur precipitated, owing to the combination of the Hydrogen with some of the Oxygen of the acid.

Observation. Other acids will have a similar effect.

CCXXX.

DECOMPOSITION of NITRATE, OR MURIATE OF MERCURY, *by Gallic Acid.*

Into a solution of Nitrate or Muriate of Mercury, pour an infusion of Galls or a solution of Gallic Acid. An Orange *yellow* precipitate will fall down.

Observation. This action of Gallic acid on mercurial salts, renders it a good test for them in solution.

CCXXXI.

DECOMPOSITION OF NITRATE OF BISMUTH,

by Gallic Acid.

Pour some of the infusion of Galls into a Solution of Nitrate of Bismuth. Although both of these liquids are nearly colourless in a separate state, yet when mixed, the whole will be converted into a brown liquid. Hence Gallic Acid is a good test for Bismuth, in combination with other bodies.

CCXXXII.

VARIATION, AS A SYMPATHETIC INK.*

Write on paper with a Solution of Nitrate of Bismuth, and smear the writing over, by means of a feather with some infusion of Galls. The letters which were before invisible, will now appear of a brown colour. If the previous use of Nitrate of Bismuth be concealed from the spectators, great surprise will be excited by the appearance of writing, merely by the dash of a feather. The same phenomenon will take place, when Infusion of Galls is written with, and the salt of Bismuth applied afterwards.

Observation. In both these Experiments, the gallic acid unites with the bismuth, forming gallate of bismuth.

CCXXXIII.

SYMPATHETIC INK,

By the Decomposition of Muriate of Antimony, by Gallic Acid.

Write with a Solution of Muriate of Antimony, and smear the writing over with a feather dipped in a Solution of Galls. The writing, before invisible, will now turn yellow, in consequence of the formation of a new substance,—the

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* Sympathetic inks are certain liquids which leave no mark on paper when written with, but appear of certain colours when other liquids come in contact with them. This phenomenon is always the result of decomposition.

Gallate of Antimony. This experiment may be reversed by writing with the Gallic Solution, and smearing with a Solution of Muriate of Antimony.

CCXXXIV.

DECOMPOSITION OF SULPHATE OF IRON,
by Gallic Acid.

Into nearly a Wine glass full of the Infusion of Galls, pour some of a Solution of Sulphate of Iron. The Gallic Acid will detach the Iron from its former combination, and in a short time, the two previously colourless fluids will be converted into one of a black colour, resembling ink. The Coloured liquid is a Solution of Gallate of Iron.

CCXXXV.

VARIATION AS A SYMPATHETIC INK.

Write on a sheet of paper, any sentence, with a transparent Infusion of Gall-nuts, and dip the paper in a transparent Solution of the Sulphate of Iron. The writing which was before invisible, will now, on a slight exposure to the air, turn quite *black*. A neater way of performing this experiment will be by smearing the written parts over with a feather dipped in the Solution of the Metallic Salt; it may also be reversed, by writing with the Salt and smearing with the infusion.

Observations. In either of these cases the iron separates from its former solvent, and unites with the gallic acid, forming gallate of iron, which greedily absorbs oxygen from the atmosphere, and is proportionally black, according to the quantity absorbed.

It is obvious from these experiments, that gallic acid and sulphate of iron are tests for the presence of each other in any liquid.

CCXXXVI.

ART OF MAKING THE BEST WRITING INK.

On the foregoing experiments, is founded the art of *Ink making*. To prepare the best, the following ingredients are to be used, viz.

4	ounces of	good Galls,
2	———	Chipped Logwood,
2	———	Sulphate of Iron,
1½	———	Gum Arabic
½	———	Sulphate of Copper,
½	———	Brown Sugar.

Boil the Galls and Logwood in six pints of spring or distilled water, until nearly three pints of water are evaporated, then strain through a piece of flannel. Powder the salts in a mortar, dissolve the Gum in a little warm water, then mix the whole together, and shake it frequently for two or three days; during which time, exposure to the air will be beneficial, as it will thereby absorb Oxygen, and become blacker. Now decant the liquor into well corked stone bottles. It is fit for use directly

CCXXXVII.

PREPARATION OF RED INK.

Infuse a quarter of a pound of Brazil wood, rasped, in two pints of Vinegar, for three days, then boil the liquid, (still accompanied by the wood) over a gentle fire, for an hour, and strain it off whilst hot. Put it again over the fire, and dissolve in it, first, half an ounce of gum arabic, and afterwards, half an ounce of alum, and the same quantity of white sugar: when the alum is dissolved, remove it from the fire, and preserve it for use.

CCXXXVIII.

SYMPATHETIC INK,

From the Decomposition of Nitrate of Cobalt by Oxalic Acid.

Write with a Solution of Nitrate of Cobalt, no marks will be apparent on the paper, but if a Solution of Oxalic acid be rubbed over it with a feather, the letters will appear first of a light, and then of a dark violet colour. The experiment may be reversed by writing with the Oxalic acid, and afterwards using the Nitrate of Cobalt.

CCXXXIX.

DECOMPOSITION OF ACETATE OF LEAD,

by Hydriodic Acid

Into a Solution of Acetate of Lead, pour some Hydriodic acid as long as a beautiful yellow precipitate continues to fall down: collect and preserve this; it is a compound of Iodine, Oxygen, and Lead.

CCXL.

DECOMPOSITION OF AMMONIA,

by Chloric Acid

Pour half an ounce of Chloric acid into a two ounce phial; let it fume for a few seconds in order to expel the common air. Next add a dram of solution of Ammonia, (Ammoniacal Gas dissolved in water) and gently shake the phial: a considerable action will now take place, and the Ammoniacal Gas will be decomposed. If the phial is now left at rest, Nitrogen Gas will be found to occupy the upper end of it.

Observation. In this experiment the chloric acid having a greater affinity for hydrogen than nitrogen has; it combines with the former substance; whilst the nitrogen is set free. The combination of chloric acid with hydrogen is hydrochloric acid,—formerly known by the name of muriatic acid.

CCXLI.

DECOMPOSITION OF HYDRIODIC ACID GAS,

by Chlorine.

Pass some Chlorine into a jar of Hydriodic acid Gas: this latter Gas will be speedily decomposed by the Chlorine, which robs it of its Hydrogen Gas, whereby Muriatic acid Gas is formed. The Iodine is accordingly set free, and appears in a gaseous form, of a very beautiful violet colour.

CCXLII.

DECOMPOSITION OF AMMONIA,

by Chlorine Gas.

Into a jar containing Chlorine Gas, pour some solution of Ammonia. Explosion will immediately take place, as the Ammonia is decomposed. Its Hydrogen, in this case, will combine with the Chlorine, whilst the Nitrogen is set free.

CCXLIII.

To vary this experiment, fill a strong phial with Chlorine Gas, and invert it over strong solution of Ammonia. Hold the phial firmly with the hand: presently a detonation will take place, and the Solution will enter the phial. Here as in the last Experiment, Muriatic Acid Gas and Nitrogen will be formed; but in this case, the Muriatic Acid Gas is absorbed by the Water, and is thus enabled to combine with the undecomposed Ammonia, forming Muriate of Ammonia.

CCXLIV.

PREPARATION OF SULPHURET OF CHROMIUM,

M. Lassaigne's mode of preparing this Sulphuret is thus described in the *Annales de Chimie.*

" I first prepared a pure Muriate of Chrome, by boiling together dry Chromic Acid with an excess of Muriatic Acid, and evaporating to dryness in a porcelain dish ; in this state it was a loose puffy rose-coloured salt. I then powdered it, mixed it with five times its weight of Flowers of Sulphur, put the mixture in a bent glass tube, and gradually heated it to whiteness.

" At the beginning there was given out a little Sulphureted Hydrogen and Muriatic Gas, afterwards came over the excess of Sulphur with a little rose-coloured Muriate of Chrome, and at last very thick white vapours of a disagreeable pungency, which I recognised for Chloruret of Sulphur, made their appearance, and continued to the end of the calcination.

" The lower part of the tube inclosed a blackish-grey and very light mass, easily falling to powder on the slightest pressure, which many experiments have convinced me is true Sulphuret of Chrome.

Observations. Properties of the Sulphuret. It is blackish grey, and unctuous to the touch, leaving on paper black shining streaks, like black-lead. When heated to cherry-red in a small platina crucible it burns like pyrophorus, giving out a strong Sulphureous smell, and leaving a very deep green oxyd of chrome. Nitric acid, even when heated, has no sensible action on this Sulphuret ; but nitro-muriatic acid changes it to sulphuric acid, and green muriate of chrome."

CCXLV.

MERCURY TARNISHED

by Sulphuretted Hydrogen Gas.

Into a phial containing Water impregnated by Sulphuretted Hydrogen Gas (Harrowgate Water,) pour a dram of Mercury, and shake the phial. The Mercury will be rendered completely black in a few minutes, being converted into the state of Sulphuret.

Observation. A similar phenomenon will take place, if silver be immersed in this water.

CCXLVI.

WHITE OXIDE OF LEAD TARNISHED

by Sulphuretted Hydrogen Gas.

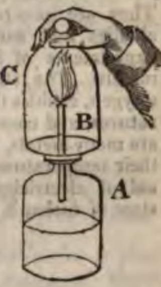
If a piece of Wood, painted white, be moistened, and Sulphuretted Hydrogen Gas be made to play upon it from a bladder, it will instantly turn black. The same effect will take place, if a piece of painted wood be immersed in water impregnated with this Gas.

CCXLVII.

WATER FORMED BY THE DECOMPOSITION

of Atmospheric air; during the Combustion of Hydrogen Gas.

Hold a small glass jar over a stream of *inflamed* Hydrogen Gas issuing from a brass or glass tube fixed in the cork of a vessel where Hydrogen Gas is generated. The sides of the jar will in a few minutes be clouded with condensed vapour formed by an union of the Oxygen of the Atmospheric air, and the Hydrogen which undergoes combustion. If the combustion is kept up, drops of water will be seen to trickle down the sides of the jar. Annexed is a figure of the necessary apparatus: but the experiment may be performed by holding a glass jar over one of those Gas-light tubes which are fixed on shop counters.



Observations. This experiment shows the necessity of having a chimney to carry off the aqueous vapour, where the gas lights are burned in shops, &c. especially in those of ironmongers and cutlers.

CCXLVIII.

PREPARATION OF HYDRIODIC ACID.

Make a Solution of Iodine in water, and pour into it, water impregnated with Sulphuretted Hydrogen Gas as long as a precipitate of Sulphur falls down. Here the Hydrogen and Iodine combine, setting the Sulphur free. The Solution is now to be poured into a Retort placed in a sand bath; and a gentle heat kept up to evaporate the excess of water; this heat should not exceed 240° or 250°, as, at a little above that, the Acid itself is rendered volatile. Preserve it in a well stopped phial.

Observations. If a quantity of sulphuretted hydrogen gas be passed through a solution of Iodine in water, as long as sulphur is precipitated, hydriodic acid will be obtained. Evaporation, in order to condense the acid is here likewise useful.

CCXLIX.

OXIDATION OF METALS,

by Decomposition of Atmospheric Air.

Expose a small piece of Metallic Manganese to the action of a moist atmosphere. In a short time, this metal will lose its lustre, and become covered by a coat of black Oxide. If left for a day, the whole will be Oxidised, and consequently, losing its tenacity, will crumble to pieces. Similar phenomena will take place, and in less time, if Sodium or Potassium are exposed in the same way;—these metals being converted into Soda and Potass, which substances are in the state of Oxides.

Observations. Metallic oxides are compounds of metals with oxygen. They are generally in the state of powders of various colours. The alkalies and earths were considered simple bodies until the interesting experiments of Sir H. Davy proved them to be oxides of peculiar metals. The strong affinity which exists between some metals and oxygen, enables them to decompose atmospheric air at common temperatures, and consequently they attract the oxygen to themselves. There are many metals, however, which cannot decompose atmospheric air until their temperatures are considerably raised, and it requires the powerful aid of electricity and galvanism to oxidise a few of them. Lead in a state of fusion is readily oxidised.

CCL.

DECOMPOSITION OF WATER,

by Red hot Iron.

Plunge a red hot poker into a vessel containing water; Hydrogen Gas will arise from the vessel: clouds of steam will also arise. Here the Iron at a red heat has more affinity for Oxygen than Hydrogen has in its usual state of combination; consequently the Metal is oxidised whilst the Hydrogen is set free.

CCLI.

SLOW DECOMPOSITION OF WATER BY IRON-FILINGS.

Put some Iron-filings in a saucer, moisten them with water, and put the saucer under a bell-glass. If in a few days the glass be examined, it will be found to contain *Hydrogen Gas.* Here the Iron has been oxidised by the

Oxygen of the Water; consequently the Hydrogen is set free.

CCLII.

ONE METAL MAY BE OXIDISED AT THE EXPENCE *Of another.*

Put into a retort two ounces of Iron-filings and two ounces of red Oxide of Mercury; give sufficient heat for the distillation of the Mercury, it will pass over in its pure metallic state. Here the Mercury at a certain heat has less affinity for Oxygen than Iron-filings, consequently the Iron is left in the retort in an oxidised state.

CCLIII.

MOLYBDIC ACID DEOXIDATED BY TIN.

Immerse a piece or rod of Tin in diluted Molybdic Acid; a blue colour will immediately pervade the fluid. This is owing to the combination of a part of the Oxygen of the Acid with the Tin. A part of the Molybdic Acid will consequently be converted into the Molybdous.

Observation. A similar effect will be the result of an immersion of zinc in the molybdic acid.

CCLIV.

PREPARATION OF THE PURPLE OXIDE OF GOLD, *Generally termed the Purple Precipitate of Cassius.*

In a solution of Nitro-Muriate of Gold, immerse a plate of Tin; a purple precipitate, which is the Oxide of Gold, will immediately take place on it; wipe this off with a feather; and continue immersing the plate as long as a precipitate takes place. Dry the Oxide and preserve it.

Observation. In this experiment the nitro-muriatic acid in seizing upon the tin deposits the gold upon it; thereby shewing that a greater affinity subsisted between the acid and the tin, than between the acid and the gold.

CCLV.

DECOMPOSITION OF METALLIC SULPHURETS.

By the intervention of heat, one metal may combine with Sulphur by robbing another of it.

Put into a retort equal weights of Vermillion (Sulphuret of Mercury) and Iron-filings; apply considerable heat: pure Mercury will be distilled.

Observation. Here at an elevated temperature sulphur evinces greater affinity for iron than for mercury; consequently, the mercury will be restored to its metallic state, whilst sulphuret of iron will be found in the retort.

CCLVI.

COMPARATIVE AFFINITY OF SEVERAL SUBSTANCES FOR *Sulphuric Acid. Ammonia greater than Iron.*

Prepare a solution of Sulphat of Iron in a tumbler, and drop into it as much Ammonia as will precipitate the whole of the oxide of Iron. Here the superior affinity of Sulphuric Acid for Ammonia is evident, and the new formed compound will be Sulphate of Ammonia, which crystallizes in six sided prisms. If Carbonate of Ammonia has been used, the precipitate will, instead of the Oxide, be the Carbonate of Iron.

CCLVII.

MAGNESIA GREATER THAN AMMONIA.

Let the precipitate formed in the last experiment, subside; and pour off of the supernatant liquor into another clean tumbler. Now stir in the liquid as much Carbonate of Magnesia as will be dissolved. The preference of Sulphuric Acid for Magnesia will be known by the discharge of Carbonate of Ammonia in the state of Gas. Sulphate of Magnesia will be held in solution.

CCLVIII.

SODA GREATER THAN MAGNESIA.

Into the newly formed solution of Sulphate of Magnesia, pour a solution of Carbonate of Soda until the whole of the Magnesia shall be precipitated in the state of a Carbonate. The liquid will now be a solution of Sulphate of Soda.

CCLIX.

POTASS GREATER THAN SODA.

Into the solution of Sulphate of Soda now made, pour a solution of Carbonate of Potass, until effervescence just commences. Here the Carbonic Acid leaves the Potass, and the Soda combines with it; the Soda thus receives a dose equivalent to what it lost to the Magnesia, when poured into the solution of Sulphate of Magnesia.

Observations. Although in this experiment, no precipitate falls down, still the decomposition of sulphate of soda takes place. This may be known by the crystallization of sulphate of potass, and carbonate of soda. The crystals of sulphate of potass are of a prismatic form with six sides, and pyramidal tops.

The commencement of effervescence when the carbonate of potass is poured in, denotes that the soda is completely saturated with carbonic acid, and when it cannot combine with more, this acid is discharged.

CCLX.

STRONTIAN GREATER THAN POTASS.

Into the newly formed solution of Sulphate of Potass pour a solution of pure Strontian in cold water, or of Carbonate of Strontian in hot water; the Sulphuric Acid will now make another change, by leaving the Potass and combining with the Strontian, which compound, when cold, (if the solution has been hot) will be precipitated. When crystallized, Sulphate of Strontian takes the form of needles crossing each other.

CCLXI.

BARYTES GREATER THAN STRONTIAN.

Dissolve the last mentioned precipitate in boiling water, and pour in a solution of Barytes, or Muriate of Barytes. The Sulphuric Acid will now make one more election, seizing on the Barytes, and forming with it a very insoluble salt, the Sulphate of Barytes.

Observations. Throughout the foregoing experiments we have seen the comparative affinity existing between the different substances operated upon, for sulphuric acid. Ammonia takes it from oxide of iron; magnesia from ammonia; soda from magnesia; potass from soda; strontian from potass; and barytes from strontian.

CCLXII.

DECOMPOSITION OF PRUSSIATE OF IRON,(PRUSSIAN BLUE)

By pure Potass.

Put some powdered Prussian Blue into a florence flask containing a solution of pure Potass; place the flask in a sand bath, or over a lamp. When filtered, the solution will be quite clear being Prussiate of Potass. Oxide of Iron will remain on the filter. Here by decomposition, the Prussiate of Iron loses its blue colour.

CCLXIII.

DECOMPOSITION OF GALLATE OF IRON,

(common Writing Ink) by Potass.

Into a solution of Gallate of Iron, pour a solution of

Potass; the intense black colour will disappear greatly. It a paper written upon be immersed into a solution of Potass the letters will be almost effaced. But if the paper be afterwards dipped in a Gallic infusion, the black colour will be restored; the same will happen if the infusion is added to the decomposed Ink.

CCLXIV.

CHANGE OF COLOUR PRODUCED BY THE ACTION OF *Potass on the Nitrate of Cobalt.*

Pour a dram of Nitrate of Cobalt into a small phial containing an ounce of a solution of pure Potass. The Oxide of Cobalt will be precipitated of a blue colour. If the phial be now corked, the blue colour will disappear, and a lilac one will succeed it; this will afterwards become lighter, or of a peach-blossom hue; and a light red colour will finish the number of changes.

CCLXV.

PRECIPITATION OF OXIDE OF GOLD FROM THE *Nitro-Muriatic Solution, by Potass.*

To a solution of Gold in Nitro-Muriatic Acid, or in Chlorine, add a solution of Potass. The precipitate which falls down will be of a dark brown colour. The supernatant liquid will be Muriate of Potass. Filter the whole and dry the precipitate gently. Preserve this Oxide in a phial.

CCLXVI.

PREPARATION OF GREEN OXIDE OF NICKEL.

Dissolve three or four drams of Nickel in some diluted Nitric Acid. When perfectly dissolved, pour in a solution of Potass. A beautiful green precipitate, which is the Oxide of Nickel, will fall down. Filter, dry and preserve the powder. Here the Nitric Acid leaves the Nickel, and with the Potass forms Nitrate of Potass. This Oxide is used as a pigment.

CCLXVII.

PRECIPITATION OF OXIDE OF TIN

From the Nitrate, by Potass.

Into a saturated solution of Tin in Nitric Acid, pour a solution of Potass. A precipitate of yellow Oxide of Tin will fall down. Filter and preserve the Oxide. The remaining liquid, by evaporation, will yield crystals of Nitrate of Potass.

CCLXVIII.

To PROCURE THE YELLOW OXIDE OF PLATINUM.

Into a diluted solution of Muriate of Platinum, pour a little of the Solution of Potass; a yellow precipitate will fall down: this is Oxide of Platinum. Filter, dry, and preserve the powder.

Observation. In these precipitations, the acids evince a greater affinity for potass than for the metals.

CCLXIX.

DECOMPOSITION OF MURIATE OF AMMONIA,

by pure Soda.

To a solution of Muriate of Ammonia, add some caustic Soda: a pungent odour will be perceived if the nose be held over the vessel in which the action is going on. This is occasioned by the disengagement of Ammoniacal Gas. In this experiment the Muriatic Acid combines with the Soda whilst the Ammonia escapes. The liquid will yield crystals of Muriate of Soda.

Observation. A similar result will also take place with lime. To a solution of muriate of ammonia in a wine-glass, add some lime-water. The lime will combine with the muriatic acid, forming muriate of lime, whilst the ammonia will be disengaged, and made sensible to the smell, if the nose is held over the glass.

CCLXX.

To PREPARE AMMONIURET OF COPPER.

To a solution of Sulphate of Copper, add pure Potass as long as Oxide of Copper falls down: or to a solution of Nitrate of Copper add pure Lime, or Lime water. Filter and wash the precipitate. To this Oxide, in a Florence flask, add some pure liquid Ammonia; and place the flask over a lamp. The Oxide will be dissolvéd, and the liquid will have a beautiful blue colour. This is the Ammoniuret of Copper. Evaporate this solution gently, it will yield beautiful crystals of a satin lustre.

CCLXXI.

ACTION OF AMMONIA ON SULPHATE OF ZINC.

Pour into a solution of Sulphate of Zinc, a little pure liquid Ammonia. A white precipitate will instantly take place, which will however be almost as instantly dissolved. This precipitate will pervade the fluid like an evanescent cloud.

CCLXXII.

DECOMPOSITION OF NITRATE OF NICKEL BY AMMONIA.

Pour some pure liquid Ammonia into a solution of Nitrate of Nickel; a blue precipitate of Ammoniuret of Nickel will fall down; care must be taken not to add too much Ammonia, as the precipitate may be re-dissolved. This precipitate will in a little time turn to a beautiful light purple, and from that to a violet colour. If a very diluted acid be poured over it, it will resume its grass green colour as before precipitation. Ammonia, from this property of changing colour, when combined with the Oxide of Nickel, is an excellent test for any of the salts of that metal.

CCLXXIII.

PRECIPITATION OF SILEX FROM SILICATED FLUORIC GAS.

Prepare a jar of Silicated Fluoric Gas over water, leaving about half a pint of water in the jar. Cork it well under water, and lay it aside, or agitate it so as to cause an absorption of the gas, which will quickly take place. When the whole is absorbed, pour half an ounce of the impregnated fluid into six or eight drams of pure water of Ammonia; a white precipitate of pure Silex will fall down.

CCLXXIV.

DECOMPOSITION OF NITRATE OF COPPER BY LIME;

Forming Oxide of Copper, or Blue Verditter.

To a solution of Nitrate of Copper, add Lime or Lime-water as long as any green precipitate falls down. Filter the solution and dry the precipitate; which must be ground and kept quite free from dust. The green colour will by this time be converted into a beautiful blue.

CCLXXV.

PRECIPITATION OF GELATINE FROM ITS SOLUTION,

By Alcohol.

Pour two drams of pure Alcohol into a wine-glass containing four drams of melted size: an immediate precipitate, or rather coagulum, of Gelatine will be formed. Here the affinity of the Alcohol for the water prevails over that of the Gelatine for the water. Consequently the supernatant liquid will be diluted Alcohol, or spirit.

CCLXXVI.

DECOMPOSITION OF MILK BY ALCOHOL.

If one ounce of Alcohol is poured into half a pint of milk, the latter will be decomposed, and a copious white precipitate will fall down. Here the Alcohol combining with the water, the Albumen and oil fall down in the state of curd.

CCLXXVII.

DECOMPOSITION OF NITRO-MURIATE OF GOLD

By Ether: or to prepare an Ethereal Solution of Gold.

Pour one ounce of the solution of Nitro-Muriate of Gold into a graduated glass; and over it three drams of Sulphuric Ether: stir the two liquids with a glass rod, so that intimate combination may take place. Let the fluids rest for two or three minutes, covered over to prevent evaporation; the Ether from its lightness will occupy the upper part of the glass, and may be gently poured off into a phial for use. This phial should have a ground stopper, round which a piece of leather is to be firmly tied.

Observations. In this experiment the ether itself, a remarkably light substance, combines with a heavy metal, or rather the oxide of the metal which it detaches from its former solvent and bears to the top. This is accounted for by the very minute portion of gold which has been held in solution by one ounce of the diluted muriatic acid; consequently the specific gravity of the ether must be very little increased.

CCLXXVIII.

ETHEREAL SOLUTION OF PLATINUM.

Into one ounce of the solution of Muriate of Platinum, pour three drams of Sulphuric Ether, proceed in all other respects as in the preparation of the Ethereal solution of Gold, in the last experiment.

CCLXXIX.

PRECIPITATION OF SULPHUR FROM SULPHURIZED

Alcohol, by Water.

Into a wine-glass of distilled water pour a little Sulphurized Alcohol: an immediate precipitation of Sulphur will take place from the greater affinity existing between Alcohol and water than Alcohol and Sulphur.

CCLXXX.

DECOMPOSITION OF RESINOUS TINCTURES BY WATER.

Pour half an ounce of Compound Tincture of Benzoin, Tincture of Kino, or of any other resinous Tincture, into a wine-glass full of water. A very flocculent and abundant precipitate of the Resin will take place, the Alcohol having united with the water, for which it had greater affinity, than for the Resin.

CCLXXXI.

DECOMPOSITION OF A SOLUTION OF CAMPHOR IN ALCOHOL,

By Water.

Pour half an ounce of the Alcoholic solution of Camphor into a dry wine-glass; and add nearly the same quantity of clear water to it. The mixture will immediately become quite turbid, and of the appearance of curdled milk: being an opaque fluid produced by the mixture of two transparent ones. Here the water seizes upon the Alcohol and precipitates the Camphor in the form of white flocks.

CCLXXXII.

PRECIPITATION OF WHITE OXIDE OF ANTIMONY

From the Muriate, by Water.

Into a solution of Muriate of Antimony, pour some distilled water: the white Oxide will be precipitated. Here the acid evinces a greater affinity for water than for the metallic Oxide.

CCLXXXIII.

DECOMPOSITION OF NITRATE OF BISMUTH

By Water; or the preparation of Pearl White.

Pour some distilled water into a solution of Nitrate of Bismuth as long as precipitation takes place; filter the solution, and wash the precipitate with distilled water as it lies on the filter. When properly dried, by a gentle heat, this powder is what is generally termed Pearl White.

CHAPTER VII.

EXPERIMENTS ON COMPOUND, OR, DOUBLE, AFFINITY.

DOUBLE Affinity is that mutual action which is induced between the component substances of two compound bodies, when these are by any means brought into contact with each other. In such cases, each compound body is *decomposed;* but two other bodies are immediately formed of their constituents, differing essentially from those submitted to experiment.

Decomposition takes place when a compound body is divided into two or more simple ones; thus, water may be decomposed and resolved into its constinent parts; viz. Oxygen and Hydrogen.

Recomposition takes place when two or more bodies are made to unite by chemical affinity, and to form some other substance different from those employed in the recomposition: thus, by certain methods, Oxygen and Hydrogen may be made to unite in such proportions as to form water a substance, totally different from the nature of either; for the constituents are *gaseous,* and the compound *liquid.* By experiments in both ways, then, we must be satisfied that Water is a compound of Oxygen and Hydrogen. In the same way all other compound substances may be decomposed and recomposed. The following examples will illustrate this mode of action.

CCLXXXIV.

Mutual decomposition of Carbonate of Soda, *And Muriate of Barytes.*

Pour a little of the solution of Carbonate of Soda, into a solution of Muriate of Barytes in a wine glass. Here a mutual decomposition takes place; and Carbonate of Barytes and Muriate of Soda will be formed. The Muriate of Soda will be held in solution, and may be crystallized into that salt known by the name of *Table Salt:* whilst the Carbonate of Barytes is precipitated in a very heavy white Powder.

Observation. A similar action will take place between sulphate of soda and muriate of barytes.

CCLXXXV.

MUTUAL DECOMPOSITION OF NITRATE, OR MURIATE *Of Cobalt, and Carbonate of Potass.*

Into a solution of Muriate of Cobalt, pour some of the solution of Carbonate of Potass, mutual decomposition will take place, and a precipitate of a most beautiful light violet colour will fall down. This ,precipitate will in a short time, change to a full violet hue.

CCLXXXVI.

SULPHATE OF MAGNESIA AND CARBONATE OF POTASS.

Pour a solution of Carbonate of Potass into a tumbler, containing a solution of Sulphate of Magnesia. A white precipitate of Carbonate of Magnesia will fall down, as the Salts continue to decompose each other.

Observation. Here the potass quits the carbonic acid from its greater affinity for sulphuric acid, and thus sulphate of potass is formed and held in solution; on the other hand, the carbonic acid unites with the magnesia and falls down with it.

CCLXXXVII.

CARBONATE OF POTASS AND SULPHATE OF IRON.

Pour some of the solution of Carbonate of Potass into a solution of Sulphate of Iron in a wine glass. A mutual decomposition, by double affinity, will immediately take place, when Sulphate of Potass will be held in solution, and Carbonate of Iron will be precipitated.

Observation. If a solution of pure potass be used instead of the carbonate, oxide of iron will be precipitated, whilst sulphate of potass remains in solution.

CCLXXXVIII.

CHROMATE OF LEAD AND CARBONATE OF POTASS; *Or the preparation of Chromate of Potass.*

Pulverize four ounces of the Siberian Chromate of Lead

Ore, which is of a reddish colour, put it into a flask or other glass vessel, and pour over it a solution of eight ounces of Carbonate of Potass in a pound of Water: set the vessel over a lamp and let it boil, as long as Carbonate of Lead falls down. Filter the whole, and preserve the solution of Chromate of Potass in a stoppered bottle.

Observation. This salt is not only useful as a test for metallic solutions, but affords the most brilliant results in precipitating the metals in combination with itself, whereby pigments of unrivalled beauty and great variety are obtained.

CCLXXXIX.

NITRATE OF COPPER AND ARSENIATE OF POTASS; *Or the preparation of Arseniate of Copper, commonly called Scheeles Green.*

To a solution of Nitrate of Copper, add a solution of Arseniate of Potass. The fluid will be of a beautiful intense green colour, having an abundant precipitate of Arseniate of Copper. Filter the whole, and wash the precipitate. A solution of Nitrate of Potass will pass through the filter, and may be crystallized.

CCXC.

CHROMATE OF POTASS AND ACETATE OF LEAD; OR, *The preparation of Chromate of Lead.*

To a solution of Acetate of Lead, add a solution of Chromate of Potass as long as precipitation takes place. Here a double decomposition is induced, whereby Acetate of Potass is held in solution, and Chromate of Lead is precipitated. This salt is of a most beautiful orange colour, and is used in painting.

CCXCI.

NITRATE OF BISMUTH AND CHROMATE OF POTASS; *Or, the preparation of Chromate of Bismuth.*

To a solution of Nitrate of Bismuth, add a solution of Chromate of Potass, as long as a lemon coloured precipitate falls down. This is Chromate of Bismuth; Nitrate of Potass will be held in solution.

CCXCII.

CHROMATE OF POTASS AND SULPHATE OF ZINC; OR,

The preparation of Chromate of Zinc.

Add a solution of Chromate of Potass, to a solution ot Sulphate of Zinc, as long as a precipitate falls down. This precipitate which will be of a bright yellow colour, is Chromate of Zinc, Sulphate of Potass will be held in solution.

CCXCIII.

NITRATE OF SILVER AND CHROMATE OF POTASS;

Or the preparation of Chromate of Silver.

Into a solution of Nitrate of Silver, pour a solution of Chromate of Potass; Chromate of Silver and Nitrate of Potass will be formed by double affinity and decomposition. The last will be held in solution, whilst the first is precipitated. This precipitate is of a most beautiful red colour, possessing the brilliancy of *Carmine.*

CCXCIV.

CHROMATE OF POTASS AND NITRATE OF MERCURY;

Or the preparation of Chromate of Mercury.

Pour a solution of Chromate of Potass into a solution of Nitrate of Mercury. Double decomposition and recomposition will be the consequence. Chromate of Mercury an intensely red and beautiful salt like Vermillion, will be precipitated, whilst Nitrate of Potass is held in solution.

CCXCV.

PRUSSIATE OF POTASS AND CARBONATE OF IRON.

Dissolve some Carbonate of Iron in a glass of water, (or take some mineral water impregnated with this salt,) and pour in gradually, a solution of Prussiate of Potass. The Prussic Acid will leave the Potass and attach itself to the Iron, setting the Carbonic Acid free, which in its turn seizes upon the Potass. The colour of this mixture will be *blue;* Prussiate of Iron (Prussian Blue) being held in solution.

CCXCVI.

SULPHATE OF IRON AND PRUSSIATE OF POTASS

Or the, preparation of Prussian Blue.

If a solution of Sulphate of Iron, is made in a tall beer glass, and a solution of Prussiate of Potass dropped into it, a very beautiful blue colour will be produced, this may be much heightened by pouring in more until all the Iron is taken up. Here the Prussic Acid leaves the Potass, and seizes upon the Iron, forming Prussiate of Iron, whilst the Potass in its turn is taken up by the Sulphuric Acid, forming Sulphate of Potass. In this way, the least portion of Iron may be detected in any solution.

CCXCVII.

VARIATION AS A SYMPATHETIC INK.

If a letter be written with a solution of Sulphate of Iron, the writing will be invisible; but if it be afterwards rubbed over by a feather, dipped in a solution of Prussiate of Potass, it will appear of a beautiful blue colour.

Observations. The following mode of manufacturing prussian blue, on a large scale, is described in the Journal de Physique: it is of German invention.

Any quantity of horns and hoofs is to be mixed with an equal weight of clippings of leather, and the whole submitted to distillation in a large iron retort, fixed in a reverberatory furnace; the oil and impure ammonia, resulting from this process, are collected in a receiver, and the distillation is carried on at a high heat, till no fluid or vapour of any kind come over—the oil and alkali are disposed of to different manufacturers, and *the black spongy coal remaining in the retort is the only part made use of in the preparation of the Prussian blue.*

Ten pounds of this coal, and thirty pounds of common potash, are reduced together to a coarse powder, and heated to redness in an iron pot; by degrees the mass is brought into a state of *semifusion,* in which it is suffered to continue twelve hours, when the matter gives out a strong odour of sulphur; it is then taken out red hot, and thrown into a boiler of water, where it undergoes ebullition for about half an hour. The clear liquor is separated by filtration, and the residue is boiled in fresh parcels of water, till all the saline matter is extracted. These different lixivia are then mixed together. Four pounds of alum, and one and a half of sulphate of iron, are dissolved in warm water, and this solution is added to the former; a copious whitish precipitate is immediately deposited, which being collected and washed, acquires, by exposure to the air, *a beautiful blue colour.*

ANOTHER METHOD IS AS FOLLOWS:

Six pounds of clippings of leather, six pounds of hoofs and horns, and ten pounds of common potash, are boiled together in an iron pot to dryness; the residue is then mixed with two pounds of crude tartar, and, by means of a strong fire, is brought into fusion. The lixiviation is conducted in the usual way, and a solution of five pounds of sulphate of iron, and fifteen of alum being added, a precipitate takes place, which is the Prussian blue.

CCXCVIII.

PRUSSIATE OF POTASS AND NITRATE OF COPPE..

Pour into a wine glass a solution of Nitrate of Copper, and add thereto a solution of Prussiate of Potass: these solutions will decompose each other by double affinity, and the results will be Nitrate of Potass, and Prussiate of Copper. The latter of these substances will give the liquid a *light brown* colour.

CCXCIX.

VARIATION AS A SYMPATHETIC INK.

Write a letter with a solution of Nitrate of Copper; the letters will be invisible, but, if they are rubbed over with a feather, dipped in a solution of Prussiate of Potass, the writing will be of a *lively brown* colour.

CCC.

MURIATE OF COPPER AND PRUSSIATE OF POTASS.

Make a solution of Muriate of copper, and add to it a solution of Prussiate of Potass; a beautiful light brown precipitate will fall down. This is the Prussiate of copper; it is to be filtered and washed. It is said to answer as a paint.

CCCI.

MURIATE OF TITANIUM AND PRUSSIATE OF POTASS.

Into a Wine glass, containing a Solution of Muriate of Titanium, pour a Solution of Prussiate of Potass. The liquid will instantly assume a beautiful green colour, which is occasioned by Prussiate of Titanium being precipitated. Muriate of Potass is held in Solution.

CCCII.

VARIATION AS A SYMPATHETIC INK.

Write a letter with a Solution of Muriate of Titanium; the letters will be invisible, but if they are rubbed over with a feather dipped in a Solution of Prussiate of Potass, they will assume a very beautiful green colour which is the Prussiate of Titanium.

CCCIII.

PRUSSIATE OF POTASS AND NITRATE OF BISMUTH.

When a Solution of one of these Salts is poured into that of the other in a glass, a very fine yellow colour will be produced; which is the Prussiate of Bismuth, in a state of precipitation. In this experiment the Nitric Acid leaving the Bismuth attaches itself to the Potass, (for which its affinity is greater) forming Nitrate of Potass: whilst the Bismuth is taken up by the Prussic Acid, forming Prussiate of Bismuth.

CCCIV.

VARIATION AS A SYMPATHETIC INK.

Write a letter with a Solution of Nitrate of Bismuth:—the letters will be invisible. If a feather be now dipped in a Solution of Prussiate of Potass, and rubbed over the Paper, the writing will appear of a beautiful yellow colour, occasioned by a formation of Prussiate of Bismuth.

CCCV.

SULPHATE OF IRON AND ACETATE OF LEAD.

Into a Solution of Sulphate of Iron, pour another Solution of Acetate of Lead as long as a precipitate continues to fall down. This precipitate is Sulphate of Lead; whilst the liquid is a Solution of Acetate of Iron. The latter Salt is much used by Dyers and Calico-printers.

CCCVI.

PHOSPHATE OF SODA AND SULPHATE OF IRON.

To a Solution of Sulphate of Iron, add one of Phosphate of Soda, until no more precipitate falls down. This precipitate, which is of a bluish colour, is Phosphate of Iron, a Salt lately used in Medicine. The supernatant liquid is a Solution of Sulphate of Soda, which may be crystallized after the liquid is filtered.

CCCVII.

ACETATE OF LEAD AND SULPHATE OF ALUMINE.

Pour into a tumbler containing a Solution of Acetate of Lead; some of the Solution of Sulphate of Alumine and Potass, or Sulphate of Alumine and Ammonia, as long as any precipitate falls down. This precipitate will be Sulphate of Lead; Acetate of Alumine will be held in Solution. This substance is a mordaunt of great use in dyeing.

Observations. The sulphate of alumine and potass, or sulphate of alumine and ammonia (common alum,) although not in the list of Experiments on the Preparation of Salts, is a very useful compound. It is manufactured on a large scale in Scotland.

Alum is used as a mordaunt for fixing vegetable colours on cloths. It is also used in tanning. Paper impregnated with a solution of it, is rendered rather incombustible; the same takes place when wood is saturated by it. It is used by tallow chandlers to harden their tallow. It is also used with a precipitate of silver, in silvering copper, brass, &c. As an astringent it is used in medicine, and in a burnt state as a caustic to remove fungous excrescences.

CCCVIII.

ACTION OF HYPO-SULPHITE OF AMMONIA

On Muriate of Silver.

When Hyposulphite of Ammonia is poured on Muriate of Silver, it dissolves it; and if into the saturated Solution Alcohol be poured, a white salt is precipitated, which must be strongly expressed between blotting paper, and dried in vacuo. It is very readily soluble in water, and is extremely sweet to the taste. Its sweetness is unmixed with any other flavour, and so intense as to cause pain in the throat. One grain of this Salt communicates a perceptible sweetness to 32,000 grains of water. If the Alcoholic liquid be evaporated, thin lengthened hexangular plates are sometimes formed, which are not altered by keeping.

Observations. When the hyposulphite of ammonia refuses to dissolve more muriate of silver, if an additional quantity be added, it is rapidly converted into a white crystallized powder. It is extremely insoluble in water, but readily and abundantly in ammonia, forming an intensely sweet solution, from which an acid precipitates it unaltered, even when copiously diluted. Dried in vacuo, and kept in a closely stopped vessel, it blackens and undergoes spontaneous decomposition. The phial, whenever opened, is found full of sulphurous acid; and when washed with ammonia, a considerable residue of sulphuret of silver is left. Heat effects the same change at once.

CCCIX.

DECOMPOSITION OF NITRATE OF SILVER,

by Muriate of Soda.

To a solution of Nitrate of Silver, in half a wine glass of water, add some of the Solution of Muriate of Soda, a white precipitate of Muriate of Silver will immediately fall down. Here the Muriatic Acid quits the Soda to unite with the Silver, whilst the Nitric Acid attacks the Soda. The two products are Muriate of Silver and Nitrate of Soda.

CCCX.

NITRO-MURIATE OF PLATINUM,

By Muriate of Tin.

Pour into a diluted solution of Muriate of Platinum in a wine glass, three or four drops of the solution of Muriate of Tin, a very beautiful scarlet precipitate of the Oxide of Platinum will fall down.

CCCXI.

NITRO-MURIATE OF PLATINUM,

By Muriate of Ammonia.

To a diluted solution of Muriate of Platinum add some of the solution of Muriate of Ammonia, an orange coloured powder will fall down.

CCCXII.

NITRO-MURIATE OF PALLADIUM,

By Muriate of Tin.

Into a solution of Nitro-Muriate of Palladium, pour a few drops of newly made Muriate of Tin: a light brown precipitate will fall down. These salts are considered good tests for the presence of each other.

CCCXIII.

NITRO-MURIATE OF GOLD,

By Muriate of Tin.

Dilute some Nitro-Muriate of Gold in nearly a wine glass of water, and drop in some Muriate of Tin. A very beautiful purple precipitate, being the Oxide of Gold, will take place, and will soon fall to the bottom: drop in more of the Muriate of Tin until no further precipitate takes place. Filter the liquid; dry and preserve the powder. This Oxide of Gold is used in the painting of China ware. In this experiment the Muriate of Tin detaches the Muriatic Acid from the Gold, which it held in solution.

CCCXIV.

VARIATION, AS A SYMPATHETIC INK.

Write with the Nitro-Muriate of Gold, and brush the letters over with Muriate of Tin in a diluted state. The writing, before invisible, will now appear of an exquisitely beautiful purple colour.

CCCXV.

MURIATE OF MERCURY,

By Muriate of Tin.

To a solution of Muriate of Mercury add a small quantity of Muriate of Tin: a black appearance will pervade the whole liquid. Hence Muriate of Tin is a good test for this very active poison (generally known by the name of Corrosive Sublimate). The precipitate is a black Oxide of Mercury.

Observation. This experiment may be varied as a sympathetic ink; proceeding as directed for other inks of this description.

CCCXVI.

DECOMPOSITION OF SULPHURET OF POTASS, &c.

By Muriatic Acid.

Put some sulphuret of Potass, or Soda, into a retort, and pour over it very diluted Muriatic Acid: Sulphuretted Hydrogen Gas will be disengaged, and may be received over Mercury in a bell glass. When the action ceases a small portion of Sulphur will be precipitated.

Observations. Here the muriatic acid attacks the alkali, forming muriate of soda, or potass; whilst the water is decomposed by part of the sulphuret; and thus the sulphuretted hydrogen will be set free.

CCCXVII.

PREPARATION OF HYDRO SULPHURET OF AMMONIA.

Put some pure solution of Ammonia into Woolfe's bottles. Into the retort pour some Muriatic Acid over Sulphuret of Potass, Soda, or Iron The Sulphuretted Hydrogen will pass over and be condensed by the solution of Ammonia; until at last, the liquid will be of a brownish yellow colour: The process is now complete, Hydro-Sulphuret of Ammonia being formed. Preserve it in a well stopped phial.

CCCXVIII.

PREPARATION OF SULPHURET OF AMMONIA.

Put into a glass retort, half an ounce of Sulphur, an ounce of Muriate of Ammonia, and an ounce of newly calcined Lime. Put the retort in a sand bath, and apply heat. A liquid of nearly the same colour as the Sulphuret of Soda and Potass will pass into the receiver. Here the Muriatic Acid of the Muriate of Ammonia attaches itself to the Lime, leaving the Ammonia free to combine with the Sulphur. The Muriate of Lime remains in the retort. Sulphuret of Ammonia should be kept in a well stopped phial.

Observations. This sulphuret, like the other alkaline sulphurets, has a great affinity for hydrogen, with which it forms sulphuretted hydrogen gas; a very useful test for metals in solution. Accordingly when a small portion of the sulphuret is put into any solution, the water is decomposed, and its oxygen left free.

CCCXIX.

PRECIPITATION OF SULPHURET OF LEAD

From the Acetic Solution, by Sulphuret of Potass.

Into a diluted Solution of Acetate of Lead, drop a small piece of Sulphuret of Potass: Sulphuretted Hydrogen will be produced by decomposition of the water: this gas has the power of precipitating Lead of a black colour.

Observation. This may be varied by writing with a solution of acetate of lead, and rubbing the writing over with sulphuret of potass in solution. The letters will be black.

CCCXX.

DECOMPOSITION OF SULPHATE OF ZINC,

By Sulphuretted Hydrogen Gas.

Into a solution of Sulphate of Zinc pour some water impregnated by Sulphuretted Hydrogen Gas, and stir the mixture. A yellowish white precipitate will soon fall down. This is Sulphuret of Zinc.

CCCXXI.

DESTRUCTION OF THE BLUE COLOUR OF AMMONIURET

Of Copper, by Sulphuretted Hydrogen Gas.

Pour into a wine glass containing a solution of Ammoniuret of Copper; about two drams of water impregnated by Sulphuretted Hydrogen Gas:—the beautiful blue colour will disappear, and a brownish black precipitate of Sulphuret of Copper will pervade the fluid.

CCCXXII.

PRECIPITATION OF SULPHURET OF ANTIMONY

By Sulphuretted Hydrogen Gas.

Make a solution of Tartrate of Antimony and Potass, by dissolving twenty grains in nearly a wine-glass of water; and drop in a small piece of Sulphuret of Potass A beautiful *deep yellow* precipitate will pervade the liquid.

CCCXXIII.

PRECIPITATION OF SULPHURET OF TIN FROM THE

Muriate, by Sulphuretted Hydrogen.

Into a wine glass containing a little diluted Muriate of Tin throw a small piece of Sulphuret of Potass. The Sulphurretted Hydrogen formed by decomposition of the water will precipitate Sulphuret of Tin.

CCCXXIV.

ACTION OF SULPHURETTED HYDROGEN GAS ON GOLD.

Pass a stream of Sulphuretted Hydrogen Gas through a solution of Gold in Nitro-Muriatic Acid as long as a black precipitate continues to fall down: this precipitate is the Sulphuret of Gold.

Observation. If the gold is to be again brought back to its metallic state; it is only requisite to throw the sulphuret into a solution of caustic potass: where it will fall down in small grains, or it may be put into a crucible, or on a hot iron: the sulphur will thus be sublimed, and the gold left in the metallic state.

CCCXXV.

PREPARATION OF SULHURET OF PLATINUM.

Pass a stream of Sulphuretted Hydrogen Gas through a solution of Platinum in Nitro-Muriatic Acid. A *black* precipitate of Sulphuret of Platinum will fall down. This powder may be obtained free by filtration.

CCCXXVI.

ACTION OF HYDRO-SULPHURET OF AMMONIA

On Muriate of Mercury.

Prepare a solution of Muriate of Mercury in warm water, and add to it a saturated solution of Hydro-Sulphuret of Ammonia in water; a *dirty brown* precipitate will fall down: this precipitate is to be left undisturbed; and at the end of several days it will be of a bright *red* colour, having gone through all the stages of *brown*, *yellow*, *and red*.

CCCXXVII.

ACTION OF OXY-NITRATE OF POTASS ON *Oxide of Silver.*

When a tube containing Oxide of Silver is dipped into a solution of Oxygenized Nitrate of Potass, a violent effervescence ensues; the Oxide is reduced, the Silver is precipitated, all the Oxygen of the Oxygenized Nitrate is liberated along with that of the Oxide; and the solution, containing merely common Nitrate of Potass, remains neutral, if it was in that state at first.

Observation. Oxide of silver produces the same effects on oxygenized-muriate of potass (Chlorate of Potass) as on the oxygenized nitrate.

CCCXXVIII.

WHITE OXIDE OF BISMUTH BLACKENED BY *Harrowgate Water.*

Place a little Oxide of Bismuth on a white dish, and pour over it some Harrowgate-water. Its beautiful white colour will instantly be changed to *black*. It is the Sulphuretted Hydrogen Gas with which the water is impregnated, that acts thus on the Oxide.

Observations. There is a curious anecdote related of the influence of this gas on the oxide of Bismuth. It is well known that this oxide, under the name of *pearl white*, is used as a cosmetic by those of the fair sex who wish to become fairer. A lady thus painted was sitting in a lecture room, where chemistry being the subject, water impregnated with sulphuretted hydrogen gas (Harrowgate-water) was handed round for inspection. On smelling this liquid, the lady in question became suddenly *black in the face*. Every one was of course alarmed by this sudden *chemical* change; but the lecturer explaining the cause of the phenomenon, the lady received no farther injury, than a salutary practical lesson to rely more upon natural than artificial beauty in future.

CCCXXIX.

DECOMPOSITION OF NITRATE OF BISMUTH BY *Sulphuret of Potass.*

Pour into a wine-glass some diluted Nitrate of Bismuth, and drop into it a small piece of Sulphuret of Potass; as soon as this latter substance is dissolved, the whole liquid will become black. Here the Sulphuret of Potass decomposes the water, attaching the Hydrogen to itself: the same is done by this substance in all situations where water is present; even in a moist atmosphere: hence the intolerable smell of Sulphuretted Hydrogen which arises from moistened Sulphuret of Potass. The Oxygen liberated by this decomposition unites to the Bismuth, whilst the Nitric Acid attacks the Potass, forming Nitrate of Potass.

Observation. This experiment may be varied by using nitrate of bismuth as a sympathetic ink, and rubbing a solution of sulphuret of potass over it. The writing, before invisible, will be converted to a black or flea-brown colour.

CCCXX.

SEPARATION OF ALCOHOL FROM WINE

By Chemical Agency.

It has been supposed that distillation causes the formation of Alcohol in Wine, Beer, &c. but this is not the case. Mr. Brande having first separated the colouring matter and acid, by a solution of Sub-Acetate of Lead, afterwards separated the Alcohol by adding to the colourless liquid, Sub-Carbonate of Potass. To eight ounces of Port wine, add an ounce of a concentrated solution of Sub-Acetate of Lead, agitate the mixture and place it upon a filter: a precipitate will remain on the filter, whilst the liquid below will be colourless: add to this, dry Sub-Carbonate of Soda until no more Alcohol can be separated. Here the water attaches itself to the salt whilst the Alcohol is set free, and the quantity will generally be one fifth of the wine employed, or about one and a half ounce. Exactly the same quantity will be recovered by distillation, which may be tried by submitting the same quantity to that operation.

Observations. Ale brewed by Sir Joseph Banks, being analysed by Mr. Brande, gave the following proportions of alcohol. Malt to the hogshead, eight strike or bushel. Hops to the hogshead, 8lbs.—contained 9.85 per cent. of alcohol. Malt to the hogshead, ten strike, Hops 11lbs.—contained 10.84 per cent. of alcohol.

CCCXXI.

WATER FORMED BY THE COMBUSTION OF ALCOHOL.

Burn four ounces of pure Alcohol, in the lamp belonging to the apparatus seen in Plate 11, receive the product of combustion through the worm, in a measuring glass partly covered on the top, so that none may be lost by evaporation. This product will be 4 ounces and a half of water.

Observations. Here, as in similar combustions, the hydrogen of the alcohol combines with the oxygen of the atmosphere; consequently water is formed. But the intense heat caused by the decomposition, gives the water the elastic form; or in other words converts it into steam. The steam, being specifically lighter than an equal sized body of air, ascends in the lengthened tube and passes into the worm: it is here condensed into water from an abstraction of the heat contained in it by the cold water in the refrigeratory:—the water in the refrigeratory may be found to become gradually warmer as the combustion proceeds; consequently the warmth or heat was obtained from the contact of the pipe, containing the hot steam, as is the case in all modes of distillation. The water produced by combustion being now condensed, passes through the worm into the measuring glass: and the increase of quantity can be inferred only, by supposing that a greater quantity of oxygen from the atmosphere, combined with the hydrogen to form water.

CCCXXXII.

PECULIAR COMPOUND OF PLATINUM OBTAINED FROM *Sulphate of Platinum, by the Agency of Alcohol.*

In the Philosophical Transactions for 1820, appear the following experiments of E. Davy Esq. on some combinations of Platinum.

Sulphate of Platinum, unlike the other metallic sulphates in general, is, to a considerable extent, soluble in Alcohol and in Ether. As these fluids are capable, in certain circumstances, of partially or wholly reviving some metallic Oxides from their solutions in Acids, I wished to try their effects on the Sulphate of Platinum. Accordingly, I put into a small phial about equal volumes of a strong Aqueous solution of the Sulphate, and Alcohol; and, after agitating the mixed fluids, the phial was put aside. Some weeks afterwards, I found the dark colour of the Sulphate had entirely disappeared, a dense black substance had subsided, and the supernatant fluid remained colourless and transparent. On opening the phial, an odour similar to that of Ether was perceived, the fluid had a strong Acid taste, and afforded a copious precipitate with Nitrate of Barytes. After the black substance had been well washed and dried, a few preliminary experiments served to show that it was a peculiar compound which had not been noticed. To confirm these results, and procure more of the substance, I repeated the experiment with the Sulphate and Alcohol. In about two days the fluid assumed a darker tint, the black substance began to precipitate in a finely divided state, and in about a week it had all subsided, leaving the fluid colourless and transparent. I afterwards found that the substance in question may be readily obtained by boiling the Sulphate and Alcohol* together for a few minutes; it separates in small particles, leaving the supernatant fluid colourless, or with only a slight tinge of yellow. In cases where it is thus procured, a little volatile inflammable fluid, having a peculiar ethereal smell, is also obtained.

Observations. This substance, after being washed till the water is tasteless, and does not affect litmus paper, and dried at a temperature of about 250° Fahrenheit, exhibits the following properties. It is of a black colour, and in small lumps, which are soft to the touch, and easily reduced to an impalpable powder. It readily soils the fingers, or paper. It is destitute of lustre. It is tasteless, and apparently unaffected either by cold or hot water. It has a peculiar ethereal smell that is not easily removed, and probably arises from the presence of a little inflammable matter occasioned by the action of the alcohol. It seems to undergo no change by exposure to the air for some time. When it is gently heated, on a slip of platinum or paper, a hissing noise or a feeble explosion is produced, and this effect is accompanied by a flash of red light, the platinum being reduced. It is insoluble in nitrous, sulphuric, and phosphoric acids; but it dissolves slowly in muriatic acid. It is scarcely affected by chlorine, unless moisture be present, when a little muriate is gradually formed. When the powder is put into liquid ammonia, minute globules of air are evolved from it, and after some time it acquires fulminating properties. The quantity of air I have hitherto obtained in this way, has been too small to allow me to ascertain its nature with precision. When the powder is brought in contact with ammoniacal gas, a crackling noise is produced, it then becomes red hot and scintillates; but by this treatment its external appearance is scarcely altered, though it undergoes a partial decomposition. The powder is immediately decomposed by the agency of alcohol. This fact is shown in an interesting manner by moistening different substances, such as paper, sand, cork, &c. with alcohol, and placing the smallest particle of the powder on them; it hisses, a sufficient degree of heat is produced to reduce and ignite the platinum, and it remains in a state of ignition until the alcohol is consumed. During the agency of alcohol on the powder, acetic acid is produced. This is shown by putting a little of the powder on a paper filter and moistening it with alcohol; a moderate action takes place, and in a few minutes the odour of acetic acid is very perceptible. In some experiments of this kind, the action, though comparatively feeble at first, has presently increased, the powder has become red hot, and the bottom of the filter completely charred. If two or three grains of the powder are placed in a glass, and a few drops of alcohol added, in about half an hour acetic acid will be produced; and as it evaporates and disappears, it may be successively renewed, at longer or shorter intervals, for some weeks, by occasionally adding a little alcohol.

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* The Alcohol used in this experiment may vary considerably in its strength and quantity, without materially affecting the results. Ether may also be employed as a substitute for Alcohol.

When the powder is boiled in alcohol, it is partially decomposed, and assumes a lighter colour; if it be then thrown on a filter, the odour of acetic acid is soon perceived, and in a few hours the platinum is found reduced and the paper charred. When the powder is mixed with flowers of sulphur, and heated, a sulphuret of platinum is formed of a blue colour. When the powder is heated with phosphorus, there is a brilliant combustion, and a dark-grey phosphuret is formed. Oxygen gas does not affect the powder at the common temperature of the air; but by a moderate heat there is a slight combustion, which seems to indicate the presence of a little imflammable matter.

COMPOSITION OF THE PECULIAR COMPOUND. In my first attempts to ascertain the nature of the black powder, I was limited to very minute quantities of it; and I made several trials before I gained any satisfactory evidences of its constitution. I decomposed the powder in long green glass tubes filled with mercury; in such cases, by a gentle heat, the powder became ignited, the reduced platinum amalgamated with the mercury, a little fluid appeared, and some gas was evolved. The fluid reddened litmus, and had an acid taste. The gas rendered lime-water turbid, and was in part absorbed by water and by ammonia; and the unabsorbed portion exhibited properties similar to those of nitrogen. These results seemed to prove, that the powder contained acid and inflammable matter; but they were not sufficiently uniform to enable me to place much reliance on them. I then used very small glass retorts, varying in capacity from $\frac{4}{10}$ to $\frac{7}{10}$ of a cubic inch, and decomposed the powder over pure water and over mercury; but the results were most satisfactory when I operated over mercury. From two experiments of this kind, I think I may venture to state the composition of the powder under examination.

Experiment 1. Ten grains of the powder were decomposed in a little retort, over dry mercury, by the heat of a spirit lamp. On the first impression of the heat, gas was disengaged, and shortly after, the interior of the retort assumed a reddish yellow colour (like that exhibited by the vapour of fuming nitrous acid), and small drops of a colourless fluid condensed in the neck of the retort. After the utmost heat of the lamp had been given to the retort, it was suffered to cool, and the results were immediately examined.

EXAMINATION OF THE GAS. The gas remaining in the retort made an ignited piece of wood glow brighter; that which came over (deducting the common air) was $\frac{34}{100}$ of a cubic inch, which diminished to $\frac{21}{100}$ on being transferred to water and agitated. $\frac{20}{100}$ of the unabsorbed gas, on being mixed with an equal volume of pure hydrogen, and fired by an electric spark, diminished to $\frac{24}{100}$. Hence, the unabsorbed portion of gas contained more oxygen than could have been furnished from the common air of the retort.

From other experiments, the gas absorbed by water was found to be carbonic acid; it rendered lime-water turbid, was absorbed by ammonia, and again disengaged by muriatic acid.

EXAMINATION OF THE FLUID. The fluid which rose in the neck of the retort reddened litmus paper, and resembled the nitrous acid in odour, colour, and taste. It acted upon the mercury in contact with the retort, and when washed out by pure water, the solution did not affect the nitrate of barytes, or silver.

The platinum was perfectly reduced, and its particles formed a loosely coherent mass, which could not be removed until the bulb of the retort was broken. It weighed $9\frac{5}{8}$ grains, and suffered no diminution on being again heated to redness in a platinum cup.

Experiment 2. Ten grains of the same powder as that used in the first experiment, afforded by its decomposition $9\frac{3}{8}$ grains of platinum, a little fluid agreeing in its properties with that noticed in the former experiment, and $\frac{34}{100}$ of gas, which was examined in a different manner from that of Experiment 1. The gas remaining in the retort was treated with pure nitrous gas; red fumes were produced, and the absorption was so great that the mercury presently rose near the bulb of the retort, and was still rising, when its neck was intentionally broken to secure the platinum. Hence it seems the gas in the retort was oxygen

The gas that came over was first treated with lime-water; an immediate turbidness was produced, and increased by agitation, and $\frac{9}{100}$ of the gas were absorbed. To the residual gas nitrous gas was added, which occasioned a considerable absorption; and the remaining gas, which exhibited the properties of nitrogen, was principally derived from the common air of the retort. By adding a little diluted muriatic acid to the turbid fluid, it immediately became transparent, the absorbed carbonic acid was slowly disengaged, and the mercury was studded with innumerable little globules of it.

From the preceding experiments, the black powder obtained by the agency of alcohol on the sulphate of platinum, appears to consist almost solely of platinum, with a little oxygen, and the elements of the nitrous acid. The very minute portion of carbonaceous matter it contains is probably accidental.* If the constitution of the powder is such as I have stated, a doubt may arise whether it can be considered as a definite compound; but its solubility in the muriatic acid, the facility with which it combines with sulphur, and resists the action of a strong solution of potash at a boiling heat, and its acquiring fulminating properties in liquid ammonia, are all circumstances which favour the notion of its being a true chemical compound.

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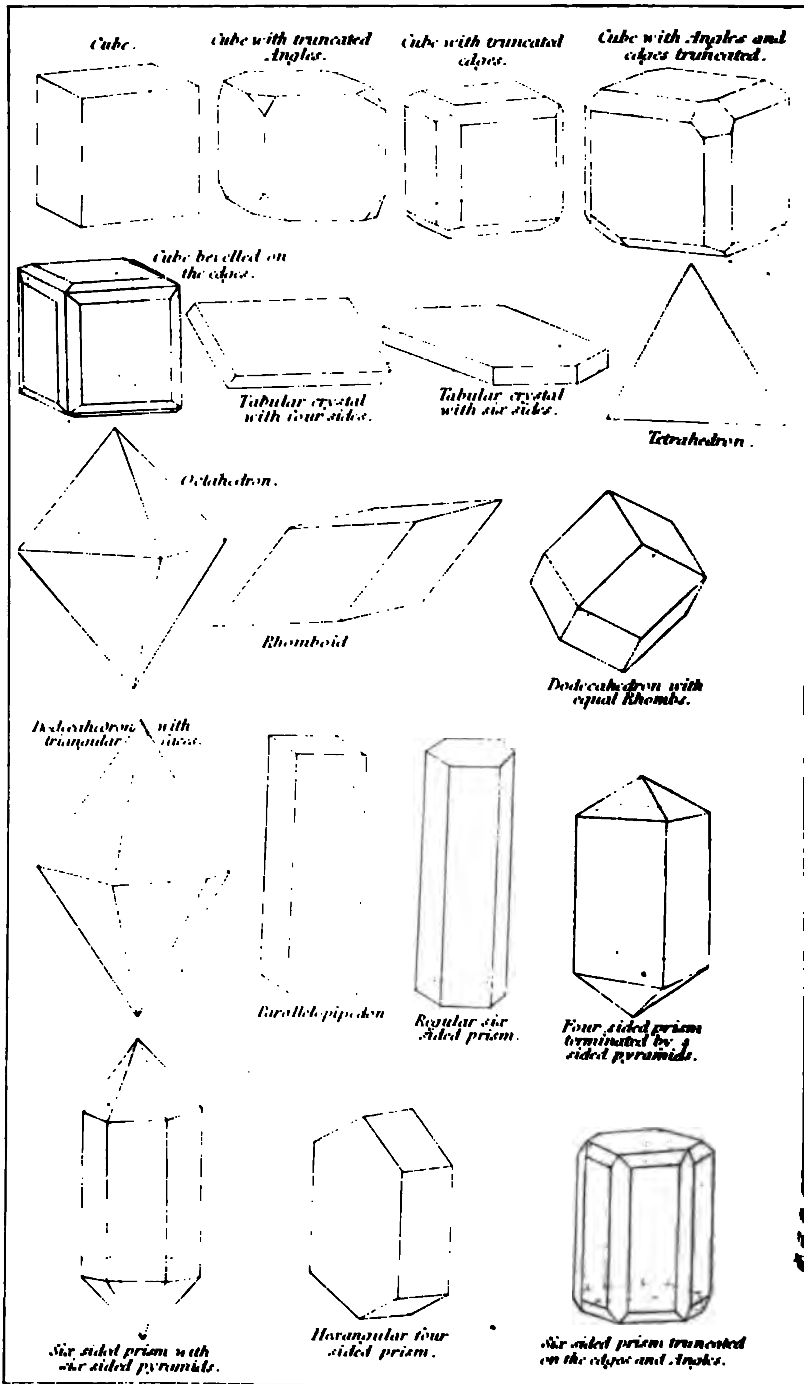
* Is it not more probable that the presence of carbon is owing to the decomposition of the alcohol, and to the abstraction of some of its carbon?

CRYSTALS OF VARIOUS FORMS.

PLATE



Cube.

Cube with truncated Angles.

Cube with truncated edges.

Cube with Angles and edges truncated.

Cube bevelled on the edges.

Tabular crystal with four sides.

Tabular crystal with six sides.

Tetrahedron.

Octahedron.

Rhomboid

Dodecahedron with equal Rhombs.

Dodecahedron with triangular faces.

Parallelepipedon

Regular six sided prism.

Four sided prism terminated by 4 sided pyramids.

Six sided prism with six sided pyramids.

Hexangular four sided prism.

Six sided prism truncated on the edges and Angles.

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CHAPTER VIII.

EXPERIMENTS ON CRYSTALLIZATION.

GENERAL OBSERVATIONS.

CRYSTALLIZATION is the assumption of determinate figures by Salts and other bodies. Hauy found, that the forms of Crystals may be reduced to six in number, viz. The Parallellopiped; the Tetrahedron; the Octahedron, the Six-sided Prism; the Dodecahedron, terminated by regular Rhombs; and the Dodecahedron with triangular faces. Figures of these, and of others more complicated are exhibited in Plate 12.

Crystals occur very frequently in the mineral kingdom, and have long attracted attention on account of their great beauty and regularity. By far the greater number of the salts likewise assume a crystalline form; and as these substances are mostly soluble in water, we have it in our power to give the regular shape of crystals in some measure at pleasure. It has long been observed by Chemists and Mineralogists that there is a particular form which every individual substance always affects when it crystallizes: this indeed is considered as one of the best marks for distinguishing one substance from another. Thus, common salt is observed to assume the shape of a Cube, and alum that of an Octahedron, consisting of two four-sided pyramids, applied base to base. Saltpetre affects the form of a six-sided prism; and sulphate of magnesia that of a four-sided prism; whilst carbonate of lime is often found in the state of a rhomboid. Not that every individual substance always uniformly crystallizes in the same form; for this is liable to considerable variations from accidental circumstances: but there are a certain number of forms peculiar to every substance, and the crystal of that substance, in every case, adopts one or other of these forms, and no other; and thus common salt, when crystallized, has always either the figure of a cube, or octahedron, or some figure reducible to these.

To explain the cause of regular figures is a difficult task. Newton remarked, that the particles of bodies, while in a state of solution, are arranged in the solvent in regular order, and at regular distances; the consequence of which must be, that when the force of cohesion becomes sufficiently strong to separate them from the solvent, they will naturally combine in groups, composed of those particles which are nearest to each other. Now all the particles of the same body must be supposed to have the same figure; and the combination of a determinate number of similar bodies must produce similar figures. Hauy has made it exceedingly probable that these integrant particles always combine in the same body in the same way; that is to say, that the same faces, or the same edges, always attach themselves together; but that these differ in different crystals. This can scarcely be accounted for, without supposing that the particles of bodies are endowed with a certain *polarity* which makes them attract one particle of another body, whilst they repel the other parts. This polarity will explain the regularity of crystallization; but it is itself inexplicable.

There are, however, some circumstances in the phenomena of crystallization, which Hauy's theory does not well explain, and his views of the primitive forms of crystallized bodies are not in every instance incontrovertibly established. Thus, a slice of *fluor spar*, obtained by making two successive and parallel sections, may be divided into acute rhomboids: but these are not the primitive forms of the spar, because by the removal of a Tetrahedron from each extremity of the rhomboid, an Octahedron is obtained. As the whole mass, then, of the spar may be divided into Tetrahedra and Octahedra, it may be doubted which of these forms is to be considered as the primitive one, especially as neither of them can fill a given space without leaving vacuities, nor can they produce any arrangement sufficiently stable to form the basis of a permanent crystal.

Dr. Wollaston has given an exposition of another view of crystallization. (Philosoph. Transact. 1813.) He has proposed, that the primitive particles of bodies should be considered as spheres, which, by mutual attraction, have assumed that arrangement which brings them as near as possible to each other. When a number of similar balls are pressed together in the same plane, they form equilateral triangles with each other; and if balls so placed were cemented together, and afterwards broken asunder, the straight lines in which they would be disposed to separate, would form angles of 60° with each other. A single ball placed on this stratum would touch three of the lower balls, and the planes touching their surfaces would then include a regular Tetrahedron. A square of four balls, with a single ball resting on the centre of each surface, would form an Octahedron; and upon applying two other balls at opposite sides of this Octahedron, the group will represent the acute rhomboid. By this view, which is highly ingenious, the difficulty of the primitive form of fluor spar, above alluded to, is obviated. By oblate and oblong spheroids other forms may be assumed.

Sir Richard Phillips, in treating on cohesive attraction, says:—The experiments of Mr. Daniell, of M. Hauy, M. Link, and others, prove incontestibly, that all solids are varieties of crystallized forms; while it requires a very slight exertion of intellect to perceive that crystallized forms are necessary consequences of atoms being packed together by the action of the atoms of any elastic medium in which they are immersed. The powers of the latter are varied only by the variable form of the atoms which are its patients during the process of evaporation and reduction of bulk. The patient atoms, therefore, are packed as it were by the incessant activity of the elastic or fluid medium in which the process takes place; and they are dovetailed, or bound together by the atoms in other forms, which mingle during the process, thereby producing united crystals, which crystals constitute what we call solids, whose density, impenetrability, and resistance of foreign action or motion, are varied according to the original form of their atoms. Atomic forms, and the relative action of other circumjacent atoms are, therefore, the sole causes of all those phenomena of cohesion in bodies."

The principles on which Crystallization depends, are concisely given by Chaptal as follows :—

A body does not crystallize, unless, by a previous division, the cohesion is broken, and the particles are enabled fully and freely to exercise their reciprocal affinities.

This division may be effected by solution; the solution is operated in water for salts, in caloric for minerals, and in alcohol for resins and certain oils.

When a body is dissolved in one or the other of these fluids, the re-union of the particles dissolved is effected by evaporation, or by lowering the temperature of the liquid.

In those cases in which the solution is performed by water or alcohol, evaporate till small crystals are formed at the surface, or on the sides; then suspend the operation, and as the liquid cools, a great quantity of salt in crystals will be precipitated. By evaporating the liquid which remains, after removing the crystals on the top, you may obtain a second quantity of crystals, and extract all the liquid from the salt by successive operations. But if the dissolution is effected by caloric alone, as in metallic fusions, and those of sulphur and phosphorus, other precautions are necessary to decide the crystallization. If you suffer a melted metal to cool, it will not fail to appear again, in consequence of the refrigeration, in its primitive form; exhibiting at the same time some confused traces, or imperfect lineaments of crystallization, such as are observed in antimony and zinc. But if at the moment when the melted metal begins to harden, you pierce the crust, and let out the metallic liquid contained within, the vacancy will be lined with regular crystals, which almost always present the cubic or octahedral form. Hence we may infer, that the metal in a mass is in reality an aggregation of crystals, and that the only method of giving it the requisite cohesion and ductility, is to beat it with the hammer, and to *weld* it.

From what has been said concerning crystallization effected by evaporation and refrigeration, we may conclude, that, after having saturated a boiling liquid with any saline substance whatever, nothing more is necessary to obtain a deposit of crystals than to let it cool. We shall easily comprehend all these phenomena, if we consider that there are then two liquids acting upon the salt, (water and caloric;) by taking away one of them, we cannot fail of having the whole of the salt, which it held in solution, for a precipitate.

When the evaporation of the solvent proceeds slowly, the crystallization is always more regular; the particles then unite and arrange themselves by virtue of their affinities; but, on the contrary, when the evaporation is rapid, the particles are precipitated upon each other, and there is nothing but confusion in their assemblage.

The slowness of the evaporation not only determines the regularity of the forms, but likewise contributes to give volume to the crystals. This we observe daily in the saline solutions which we leave in a corner of our laboratories: it is demonstrated too by all the operations of nature, which forms in time, and by insensible evaporation, saline and stony crystals; which it is impossible for us to imitate, because it is not in our power to cause ages to enter as elements into our operations.

Rest is equally necessary for the liquid, in order to obtain forms of great regularity; uninterrupted agitation prevents all symmetrical arrangement; it precipitates the crystals as fast as they are formed, and you obtain nothing, if I may so express myself, but the integral particles of crystals.

In the arts we avail ourselves of the disturbance produced by agitation in liquids to procure crystals of extreme fineness. It is by this method that we precipitate, in very small and delicate needles, the crystals of sulphate of soda, those of nitrate of potass, &c.

It frequently happens, that a solution, though complete, refuses to crystallize; in this case a slight agitation of the vessel sometimes decides the crystallization. Fahrenheit observed, that, in this circumstance, heat escaped at the moment of agitation, which seems to prove that the caloric was interposed between the particles, and that nothing but the slightest motion was wanting to disengage it.

A crystal formed in water always retains a more or less considerable portion of the liquid, and this is called the *water of crystallization.*

The only cause of solution is, that the affinity of the liquid overcomes the cohesion which connects the particles of the salt; but in proportion as the mass of the liquid diminishes by evaporation, its affinity of mass decreases, and that of the particles of the body dissolved increases, since they begin to combine with each other. There must consequently be a moment at which the affinity of the salt overpowers that of the liquid; and from this moment the salt which forms itself into crystals must retain a portion of it. This water of crystallization enters as a principle into the combination, since that liquid cannot be discovered either by the eye, or by the touch, or by hygrometrical tests.

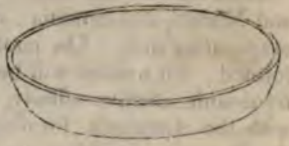
This water of crystallization contributes to give to the crystal its form, transparency, and cohesion. When it is disengaged by heat, these three characters almost always disappear. If, for example, you expose to heat a transparent crystal of sulphate of lime, you will instantly perceive the water to become volatilized and dissipated in vapour; the crystal will lose its transparency, and be rendered friable and pulverulent.

Simple substances, such as metals, certain earths, sulphur, phosphorus, resins, and, in general, all such bodies as are simple, and not soluble in water, crystallize without retaining a sensible quantity of their solvent. But compound substances require to be dissolved in a liquid, that they may there acquire the portion necessary for the formation of their crystals.

CCCXXXIII.

Crystallization of Salts.

Dissolve an ounce of Sulphate of Soda, or any other Salt, in two ounces of boiling water. Pour the solution into an evaporating dish of Wedgewood's ware, similar to that in the annexed figure; and put it into a warm place. As the water of solution evaporates, the saline matter will crystallize, resuming the same form which the crystals exhibited before being dissolved.



Observation. During the preparation of salts, the greatest cleanliness is repuired; and they should invariably be placed in situations where they may be free from dust, or the least disturbance.

CCCXXXIV.

Crystallization of different Salts, held in Solution by one Body of Water.

Dissolve in seven different tumblers, containing warm water, half ounces of Sulphates of Iron, Copper, Zinc, Soda, Alumine Magnesia and Potass. Pour them all, when completely dissolved, into a large evaporating dish, and stir the whole with a glass rod; place the dish in a warm place, where it cannot be affected by dust; or where it may not be agitated. When due evaporation has taken place, the whole will begin to shoot out into crystals. These will be interspersed in small groupes, and single crystals amongst each other. Their colour, taste, and peculiar form of crystallization, will serve to distinguish each crystal separately; and the whole together, remaining in the respective places where they were deposited, will display a very pleasing and curious appearance.

CCCXXXV.

VARIATION WITH SALTS WHOSE ACIDS AND BASES ARE DIFFERENT.

A similar effect takes place when Salts formed with different Acids and Alkalies are dissolved and poured into the same vessel. Pour a solution of half an ounce of Sulphate of Iron, and the same quantity of Muriate of Soda, together into an evaporating dish. On due evaporation each set of crystals will be formed.

CCCXXXVI.

VARIATION WHERE THE SALTS DECOMPOSE EACH OTHER.

Dissolve in warm water, half ounces of Muriate of Potass and Nitrate of Ammonia; and pour both solutions into an evaporating dish. On cooling, two kinds of crystal will be formed; but neither will be like any of those dissolved: for by double elective affinity, the Muriatic Acid will combine with the Ammonia, forming Muriate of Ammonia; leaving the Potass to be taken up by the Nitric Acid, to form Nitrate of Potass.

Observations. The following account of some experiments on the forms of artificially crystallized salts is contained in the Quarterly Journal of Science, for Jan. 1821.—M. Mitscherlich, a young chemist from Berlin, who has been much occupied in determining the form of artificially crystallized salts, has arrived at many results of very high importance respecting the relation which exists between the composition and the form of these crystals. Having studied during the last year under M. Berzelius, at Stockholm, he has repeated before him a great number of his experiments, which were found to be perfectly exact. M. Mitscherlich has discovered that several substances, simple as well as compound, *may replace one another in compound bodies, without any change of form taking place in the latter*, provided that the other constituent principles remain the same, and in the same proportions. He has found for example, that *Phosphorus* and *Arsenic* replace one another in such a manner, that the *Phosphates* crystallize in exactly the same manner as the *Arseniates* of the same bases, when they are at the same point of saturation, and contain the same number of atoms of water of crystallization, which is generally the case. The protoxides of the five following metals, viz. *iron, zinc, cobalt, nickel*, and *manganese*; the *deutoxide of copper*, and also *lime* and *magnesia*, replace one another mutually, provided always, that in the combinations which are examined, the number of atoms of water be the same. *Alumine*, the *deutoxide of iron*, and also that of *manganese*, may be substituted for one another, without any change of form.

Barytes, *strontian*, and the *oxide of lead*, are in the same predicament, and also *chlorine* and *iodine*, and *sulphur* and *selenium*, &c. To these different groups, M. Mitscherlich has given the name of *Isomorphous Bodies*.

This ingenious chemist is at present occupied in determining how many of such *isomorphous groups* exist among simple bodies, and among their different degrees of oxidation; and also in determining to what isomorphous group each of them belongs.

The discoveries of M. Mitscherlich throw great light upon mineralogy, and will give a key to an explanation of the contradictions of chemical analyses, and of the geometrical measurements of crystals; because, in a mineral species whose form has been determined with the greatest certainty, one or more elements may vary, provided that they belong to the same isomorphous class, and that the other elements remain the same. Hence, it is for this reason that lime, magnesia, the protoxide of iron, and the protoxide of manganese are substituted for one another in the Amphiboles and the Pyroxenes.

M. Mitscherlich has found also, that when several combinations, isomorphous salts, for example, are mixed in the same liquid, and when this liquid is afterwards evaporated, the isomorphous salts crystallize together, forming a part of the same crystals, and their relative proportion is then determined only by the relative quantity of each which the liquid has had to abandon at the moment of crystallization. The crystal, in short, is, as it were, built of isomorphous molecules without any chemical affinity having a share in it, and without our being able to perceive fixed and determinate proportions. This experiment is one of high importance, *as it explains the objections, which, the results of the analyses of certain minerals form, to the Theory of Definite Proportions.*

CCCXXXVII.

TO OBTAIN VERY LARGE CRYSTALS OF ANY SALT.

To obtain large artificial Crystals of a regular shape, requires considerable address and much patient attention. This curious branch of practical chemistry has been improved by M. Leblanc, who has not only succeeded in obtaining regular crystals of almost any size at pleasure, but has made many interesting observations on crystallization in general. His method is as follows.

The salt to be crystallized is to be dissolved in water, and evaporated to such a consistency that it shall crystallize on cooling. Set it by, and when quite cold pour the liquid part off the mass of crystals at the bottom, and put it into a flat-bottomed vessel. Solitary crystals form at some distance from each other, and these may be observed gradually increasing. Pick out the most regular of these, put them into a flat-bottomed vessel at some distance from each other, and pour over them a quantity of liquid obtained in the same way, by evaporating a solution of the salt, till it crystallizes on cooling. Alter the position of every crystal, once at least every day, with a glass rod, that all the faces may be alternately exposed to the action of the liquid; for the face on which the crystal rests never receives any increment. By this process the crystals gradually increase in size. When they have acquired such a magnitude that their forms can easily be distinguished, the most regular are to be chosen, or those having the exact shape which we wish to obtain; and each of them is to be put separately into a vessel filled with a portion of the same liquid, and turned in the same manner several times a day. By this treatment they may be obtained of almost any size we think proper

Observations. After the crystal has continued in the liquid for a certain time, the quantity of salt held in solution becomes so much diminished, that the liquid begins to act upon the crystal, and to redissolve it. This action is first perceptible on the angles and edges of the crystal. They become blunted, and gradually lose their shape altogether. Whenever this begins to be perceived, the liquid must be poured off, and a portion of new liquid put in its place: otherwise the crystal is infallibly destroyed. M. Leblanc has observed, that this singular change begins first at the surface of the liquid, and extends gradually to the bottom: so that a crystal, if large, may be often perceived in a state of increase at its lower end, while it is disappearing at its upper extremity. M. Leblanc even affirms, that saline solutions almost always increase in density according to their depth from the surface.

CCCXXXVIII.

PREPARATION OF SALTS.

Sulphate of Potass.

Dissolve four ounces of Carbonate of Potass in eight ounces of water, and pour in Sulphuric Acid as long as any effervescence continues; (this effervescence is occasioned by a very rapid disengagement of Carbonic Acid, which is discharged by union of the Potass with the Sulphuric Acid.) Set the solution in an evaporating dish near the fire, where dust cannot reach it; after a slight evaporation, Salts of a very beautiful pyramidal structure (Sulphate of Potass) will be formed.

Observations. Sulphate of potass is the predominating salt in the Cheltenham waters; which, according to the experiments of Mr. Richard Phillips, consist of the salt above mentioned, with a certain quantity of soda, and a very small portion of common salt (muriate of soda). The preparation usually sold under the name of Cheltenham Salts is an artificial composition of the following salts, in the proportions here stated—sulphate of soda, 120 grains; sulphate of magnesia, 60 grains; muriate of soda, ten grains; sulphate of iron, half a grain: these are simply triturated together.

CCCXXXIX.

SULPHATE OF MAGNESIA.

Put an ounce of Carbonate of Magnesia into a tumbler, and pour over it a small quantity of Sulphuric Acid: little or no action will take place; but if water be added, and the Acid poured in until the Magnesia is completely dissolved by it, (which will be known when the effervescence or discharge of Carbonic Acid Gas has ceased,) the two substances will have saturated each other. Filter the compound, and evaporate it in a tolerably warm situation; needle-like crystals will soon shoot up, and the whole will very quickly be converted into the salt known by the name Sulphate of Magnesia, or Epsom Salts.

Observations. In the large way, sulphate of magnesia is obtained from the liquor remaining after the crystallization of muriate of soda, from sea-water, which holds a quantity of it, and of muriate of magnesia in solution. This is boiled down, and when exposed to sufficient cold, affords a mass of slender needle-like crystals. This salt in a state of purity, being rather efflorescent, should be kept in close vessels, or bladders.

CCCXL.

SULPHATE OF SODA.

Pour four ounces of diluted Sulphuric Acid over a solution of Carbonate of Soda; and if effervescence still continues after repeated agitation with a glass rod, add more acid. When the liquids are saturated, expose the whole in an evaporating dish to a considerable heat. It will crystallize in six-sided prisms, which are efflorescent, and soluble in three parts of cold, or an equal part of boiling, water.

Observation. These salts have been termed Glauber's Salts. In the large way, they are obtained in decomposing sea water by sulphuric acid.

CCCXLI.

SULPHATE OF ZINC.

Pour an ounce of Sulphuric Acid diluted with three ounces of Water over an ounce of Zinc filings. An intense action will be set up as the Acid combines with the Metal; and the water will be rapidly decomposed, as may be seen from the great evolution of Hydrogen, (or rather, Hydro-Zincic Gas.) Set the solution aside to crystallize, which it will do in white masses. In the large way it is obtained by exposing the native Sulphuret to air and humidity.

Observation. This salt is remarkably astringent, and is much used for drying oil-colours.

CCCXLII.

SULPHATE OF IRON.

Pour Sulphuric Acid, diluted with eight times its weight of Water, over Iron filings in a glass vessel. The Metal will soon be dissolved, and much Hydrogen gas will be disengaged. Place the solution in a warm place to crystallize, which it will do in those light green crystals of a Rhomboidal Prismatic shape, known by the name of Copperas, Green Vitriol, or Sulphate of Iron. Some of these crystals have been obtained sixteen inches high, and ten wide. To obtain such, Dr. Black recommends pouring a little stale human urine into the crystallizing pans.

Observations. This salt is procured in the large way by the oxygenation of the native Sulphuret of Iron (Pyrites), exposed in heaps or beds to air and humidity.

Sulphate of Iron is much used in the arts, particularly by Dyers, and Hat-makers, who form a very black dye, in decomposing it by Gallic acid.

CCCXLIII.

SULPHATE OF COPPER.

Dissolve some old halfpence in diluted Nitric Acid, and when the liquid is in a saturated state, pour in a solution of Carbonate of Potass. By double affinity, two new substances will be formed, viz. Carbonate of Copper, which will be precipitated of a green colour; and Nitrate of Potass, which will be held in solution. Filter the saline solution, and pour over the Carbonate as much diluted Sulphuric Acid as will dissolve it. Evaporate the solution. Beautiful blue Crystals, known by the names of Sulphate of Copper, Blue Vitriol, or Blue Stone, will be formed. Wash the Crystals, and, when completely dried on blotting paper, enclose them in a phial.

CCCXLIV.

SULPHATE OF SILVER.

Proceed, in all respects, as in the last experiment, only using silver instead of copper: very beautiful shining needle-like crystals, which are very insoluble in water, will be formed.

CCCXLV.

MURIATE OF SODA.

Dissolve two ounces of Carbonate of Soda in four ounces of water, and pour in Muriatic Acid, until the Carbonic is completely discharged. Set the solution aside to crystallize; —the result will be Muriate of Soda;—which is that salt so much used by man with his food.

Observations. This salt is found abundantly in nature. Near the city of Wieliczka, in Gallicia, there is a salt mine of great extent. It is covered by about twenty fathoms of earth, and is divided into three stories, one below the other; each is about thirty fathoms in height, about 2000 fathoms in length, and 400 in breadth. Those who have explored these mines affirm, that whoever could devote *six hours* every day to the examination of them, would employ six weeks in visiting the whole of these subterraneous vaults.

The value of this mine is estimated at 300,000 ducats annually. Not far from this mine is another of vast extent, at Bochnia. The wonders that have been reported of these mines are calculated rather to excite astonishment, than to convey truth, but this subject of Natural History is in reality too curious and interesting, to require exaggeration.

In the first mentioned of these mines, there are four stories or floors of salt, with streets, &c. From the first story to the fourth, in descending, there are stairs nine or ten feet in width.

The first story presents a piece of architecture well entitled to attention: it is no less than a complete chapel, with all its ornaments formed out of the salt itself. It is dedicated to St. Anthony; is about thirty feet long, by twenty-four wide, and eighteen high; not only the steps of the altar, but the altar itself, the twisted columns that adorn it, and support the vault, with every ornament of the chapel, the crucifix, the statues of the virgin, and of St. Anthony, with another the size of life, representing Sigismond, are all of salt; the latter is remarkably transparent. Not far from this chapel is another dedicated to the Virgin, and about sixty paces from this is another, dedicated to St. John Nepomucendo. On certain days in the year, mass is said in these chapels in memory of events which have occurred in the mines.

The miners give the name of *streets* to the alleys which they form in working, and by the aid of a little fancy, they find houses in these streets: hence the report of a city having been built and inhabited formerly in this subterraneous abode.

Further on is a stream of fresh water, which, filtering through a layer of argillaceous sand, about four feet in thickness, runs along the mines. It serves to water the horses, and the miners themselves drink of it.

In the galleries of salt are formed recesses, where the miners deposit their tools when they quit the mine; to these they give the names of houses. The deeper the workmen penetrate, the more abundant and pure is the salt they obtain. If a few layers of earth or clay are found, they are but small, and seldom more than two feet in thickness. No volcanic productions have hitherto been found in these mines; neither sulphur, bitumen, nor coal, &c. as in many others. But many shells are found, principally Bivalves and Madrepores.

The air is wholesome in this deep abode, the galleries being formed with great attention, to preserve a communication with the external air. The workmen enter in the morning, and withdraw in the evening, but the horses never quit the mine while capable of labour, their stables and racks being all made of salt. After a short stay in this confinement, these animals become blind.

The galleries are propped up with the utmost solicitude, and during the whole time that the mine of Wieliczka has been worked, no considerable obstacle has interrupted the operations. It is thought that the mines of Wieliczka are connected with those of Bocknia distant about five miles eastward, where salt of the same kind is procured, and it was formerly the custom in both mines to work towards each other, in the same direction.

The manner of obtaining salt is as follows: the master miner marks the dimensions of a block of salt; eight feet in length, four in depth, and two feet in thickness. The miners then make a number of holes on one side, three inches deep, and about six inches asunder; they next make a kind of groove half an inch deep, connecting these holes; and place iron quoins in each of the holes, which they strike gently with mallets. As these quoins penetrate deeper into the rock, the echo of the blows, they receive, resounds throughout the mine, and has a pleasing effect on the ear; when the block is ready to part, a crack appears following the course of the holes; a workman then thrusts in a wooden pole, and working it about, the block is heard to break off from its native bed. In the mine of Wieliczka, there are from 1500 to 2000 labourers.

The water dripping from the tops of some of the galleries, has produced stalactites of surprising magnitude and beauty.

Crystals of salt are found occasionally, sometimes in small layers. These are carried to the secretary's office, where four clerks are constantly employed: and where, as in the chapels at first described, all the furniture, tables, book-case, seats, &c. are of salt. These crystals are formed into various devices, as crucifixes, chairs, coffee-cups, cannons mounted, watches, salt-cellars, &c.

This mine has been worked to the depth of 65 or 70 fathoms; it is thought the salt does not lie deeper. Some other salt mines are deeper; that of Torbax, in Transylvania, is 56 fathoms: Vizakna in 66 fathoms: Kolos 46; Izik, 47; an old mine of Deks 72; that at Ishler, on being bored, gave salt 260 feet below the lowest story then worked.

In July 1820, a regular search for rock-salt was commenced at Mogenire in the department of La Meurthe, in France, and at the depth of 200 feet there was found a bed eleven feet thick. Below this, the workmen perforated a bed of gypsum and clay of 546 feet, when they reached another bed of salt eight feet thick. The salt of the first bed was very white and transparent, and very pure: the second contained a small portion of gypsum and argillaceous substances, which were brownish like clouded flint.

CCCXLVI.

MURIATE OF AMMONIA

Pour Muriatic Acid into a solution of Carbonate of Ammonia until effervescence, by the discharge of Carbonic Acid, totally ceases. Set the solution aside, in an evaporating dish, to crystallize. The salt formed will be Muriate of Ammonia.

Observations. This salt has been prepared in many ways on a large scale. Impure Ammonia is distilled from animal substances, and combined with sulphuric acid. The new compound is then decomposed by muriate of soda:—muriate of ammonia being sublimed into a solid mass, somewhat elastic, and semi-transparent.

CCCXLVII.

MURIATE OF LIME.

Pour Muriatic Acid, diluted with eight parts of water, over some Carbonate of Lime, until effervescence ceases.—Pour the solution into an evaporating dish, and set it aside, in a warm situation, to crystallize. When the Crystals cease to form, drain off the remaining water as quickly as possible, and enclose the Crystals in ground stoppered phials for use.

Observation. This is one of the most deliquescent salts known.

CCCXLVIII.

MURIATE OF SILVER.

Prepare a solution of Nitrate of Silver, and add to it a solution of Muriate of Soda, as long as a flocculent precipitate falls down. This is Muriate of Silver obtained by double decomposition. Filter the liquid, and wash the precipitate with water; when dry, put it into a crucible and submit it to a gentle heat: this precipitate will very quickly be fused into a mass of what by the old chemists was called Luna Cornea, from its resemblance to horn of a light colour.

CCCXLIX.

CHLORATE OF POTASS.

Pour some Chloric Acid into a solution of Carbonate of Potass, until effervescence ceases: pour the mixture into an evaporating dish, and set it aside to crystallize, which it will do in brilliant white flakes. When half the crystals have been formed, pour off the supernatant liquid: dry the crystals on blotting paper. and preserve them in a well stopped phial.—The liquor poured off may also be crystallized, but the crystals, instead of Chlorate, are Muriate of Potass. Chlorate of Potass may be obtained in greater quantity, by passing Chlorine Gas through a solution of pure Potass.

CCCL.

NITRATE OF BARYTES.

Pulverize Carbonate of Barytes, and pour over it diluted Nitric Acid, until effervescence from discharge of Carbonic Acid ceases. Set the solution aside to crystallize. These crystals are sometimes in the form of shining plates, but generally in that of stars composed of several Octahedrons attached to each other.

CCCLI.

NITRATE of AMMONIA.

Dissolve some Carbonate of Ammonia in distilled water, and add to it Nitric Acid until effervescence ceases: place the solution in a warm place (temperature about 80° or 90) to crystallize. When sufficient evaporation has taken place, six sided prismatic crystals will be formed. Put these crystals into a dry and well stopped phial, for use.

CCCLII.

NITRATE OF BISMUTH.

Pour three ounces of diluted Nitric Acid into a glass vessel, and add gradually to it two ounces of Bismuth, broken by a hammer into small pieces. The metal will be attacked with great energy, and Nitrate of Bismuth will be formed. Crystallize the solution by a gentle heat, and preserve the crystals in a phial. These possess much beauty; being radiated like fire-work stars.

CCCLIII.

NITRATE OF POTASS.

This salt is found abundantly in nature; and vast quantities of it are imported from the East Indies. To obtain it pure, pour diluted Nitric Acid into a solution of Carbonate of Potass, as long as effervescence continues. Set the mixture in a warm place to crystallize, which it will do in Hexaëdral Prisms, which are soluble in six parts of cold, or in one part of boiling water.

Observations. In India this salt is found ready formed on the surface of the soil; but in France, its production has long been by artificial arrangements. Animal and vegetable substances in a state of decomposition are mixed with a quantity of carbonate of lime. The mass is exposed to the air, but protected from the rain by sheds.—Being occasionally stirred; after several months, the materials are found to contain nitrate of lime, and nitrate of potass. These salts are extracted by lixiviation with water: pure sub-carbonate of potass is now added, by which the nitrate of lime is decomposed, and the quantity of nitrate of potass encreased. The nitre is then purified, by repeated solutions and crystallizations. In this process, it is supposed that the oxygen of the atmosphere combines with the nitrogen of the animal matter to form nitric acid, and that this combines with the lime and potass of the vegetable substances.

The French, in the manufacture of saltpetre, &c.—when other nations supposed them destitute of every mode of defence against the united forces of Europe, have exhibited to the world a proud trophy of the prodigies to be accomplished by industry guided by science. The following are extracts from M. Preur's account of these gigantic operations.

" We still recollect with astonishment and admiration, the enthusiastic spirit of every Frenchman, at a time when his country was in the greatest danger, and the prodigious efforts which resulted from it, towards furnishing an enormous quantity of gunpowder and arms of every kind—of all which the nation was so much in want.

" It was necessary to give impulse to a whole nation, when the business was brought forward, of every where extracting the saltpetre earth contained in the French soil. This art was, in fact, an object almost generally unknown. Private interest was alarmed at seeing it set on foot; and still more numerous prejudices produced a variety of obstacles. Men could not be persuaded that persons so untaught, and at that time perfect strangers to the business, could all at once engage in it with success; they could not believe that France was so rich in that commodity, which never was known to be extracted in sufficient quantity for ordinary use; and of which a full supply had only been obtained by means of what was brought from India.

" In the mean time, at the invitation of the National Convention, (proclaimed by a decree of the 14th of *Frimaire,* in the second year of the Republic,) the citizens gave themselves up to the making of saltpetre. The number of buildings erected on this occasion, amounted rapidly to 6000. Necessary instructions were every where given by order of government. France was divided into large districts, each of which was continually surveyed by an inspector skilled in the arts and sciences. Under each inspector, in every department, was placed a former Director of the National Administration of saltpetre works, who appointed in each district a citizen sufficiently intelligent to preside over the formation of the offices, and to regulate the works:—thus was activity established in every place at once.

" On the other hand, a summons was issued for every district to send two robust and intelligent cannoniers to Paris, to receive instructions from the most skilful persons, who were to explain to them the art of manufacturing saltpetre, of refining it, and of converting it into gunpowder: and to some the mode of casting cannon. These pupils were then sent back into the different establishments, to assist in the works according to their capacities. Government kept up an active correspondence with all its agents: it supplied them occasionally with every necessary, and every where made easy the executive part. It was known, that every district could easily furnish a thousand weight of saltpetre every decade,* and orders were given for that quantity; places were pointed out where to send it to; the means of conveying it were fixed upon; and frequent accounts were rendered of every operation. In short, so much care produced the desired effects; and more than sixteen millions of pounds of rough saltpetre were collected in one year.

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* Every tenth day.

"It being necessary to refine this saltpetre for the manufacture of gunpowder; in a short time the refinery of L'Unité, was built on the abbey-ground of St. Germain-des-pres, at Paris. Saltpetre flowed there in profusion; and this establishment alone yielded in the refined state, regularly every day, about 30,000 pounds!—In making it into gunpowder the works of Grenelle, in five months, were so successful as to furnish the armies with no less than 1,500,000 pounds!!"

On the banks of the Merrymack and the Gasconade, in America, are found numerous caves which yield an earth largely impregnated with nitre, which is procured from it by lixiviation. At the head of Current's river were also found several caves from which nitre is procured, the principal of these is Ashley's cave on Cave Creek, about 80 miles S. W. of Potosi. This is one of those stupendous and extensive caverns, which cannot be viewed without exciting wonder and astonishment; and these sensations are increased by beholding the works for the manufacture of nitre situated in its interior. The native nitrate of potass is found in beautiful white crystals, investing the fissures of the limestone rock which form the walls of this cave. Several others in its vicinity exhibit the same phenomenon.

CCCLIV.

Acetate of Lead.

Put two ounces of Carbonate of Lead, (White Lead), into a Florence flask, and pour over it eight ounces of distilled vinegar. First give them a boiling heat, and then let them digest gently over a lamp, until the Carbonate is completely dissolved. Now pour out the solution into an evaporating dish, and let it crystallize, which it will do in masses of small shining prismatic needles.

Observation. This form of the crystals denotes that the salt has an excess of acid; but if a little Oxide of Lead be boiled with it, the acid and the metal will be saturated; and the crystals will be *tabular*, or in plates.

CCCLV.

Acetate of Zinc.

Into a solution of Sulphate of Zinc, pour a solution of Acetate of Lead as long as a precipitate falls down. Filter the whole and lay the clear liquid aside for crystallization. The precipitated white powder is Sulphate of Lead, which is a very insoluble salt; and the crystallized solution is Acetate of Zinc.

Observation. This salt, like the sulphate, is very astringent, and is used in medicine as a styptic and collyrium.

CCCLVI.

SUB-MURIATE OF MERCURY.

Put into an alembic four ounces of Muriate of Mercury, with three ounces of pure Mercury. Apply heat and sublime;—white crystals will be found in the receiver. These are the true Sub-Muriate of Mercury. When these crystals are rubbed in a mortar and ground very fine, this substance has the name of *Calomel*. It should be kept in a phial with a glass stopper, and in rather a dark place, as the light is apt to change its beautiful white ivory colour, into a dirty yellow.

Observation. The following process has lately been proposed for the preparation of calomel—prepare an Oxy-sulphate of Mercury, by boiling twenty-five pounds of mercury, with thirty-five pounds of sulphuric acid. Triturate thirty-one pounds of this dry salt with twenty pounds four ounces of mercury, until the globules disappear; and then add seventeen pounds of common salt (muriate of soda.) The whole must be thoroughly mixed, and sublimed in earthen vessels.—Between forty-six and forty-eight pounds of pure calomel are thus produced. It is to be washed and levigated in the usual way.

CCCLVII.

CARBONATE OF AMMONIA.

Pulverize four ounces of Muriate of Ammonia and six ounces of Carbonate of Lime. Put this in a mixed state into a dry stone-ware retort or alembic, and give it a good heat. An elastic vapour will come over, and will be condensed on the sides of the receiver in small shining filaments. These are minute crystals of Carbonate of Ammonia. They have a pungent odour. The Muriatic Acid unites with the Lime in the retort, forming Muriate of Lime, which should be washed out with water and crystallized.

Observation. Another mode of preparing this salt on a small scale, is to pour some diluted sulphuric acid over powdered chalk in a tubulated retort, and to put the beak under a jar of ammoniacal gas, placed in a pneumatic mercurial trough;—sulphate of lime will be formed in the retort, whilst the carbonic acid quits the earth, and attaches itself to the alkali in the jar, forming a solid substance, viz. the carbonate of ammonia. This will be deposited on the sides, in the form of very beautiful white small filaments.

CCCLVIII.

PHOSPHATE OF SODA.

Pulverize some Phosphoric Acid, and dissolve it in water; to the clear solution, add Carbonate of Soda, as long as effervescence, by the escape of Carbonic Acid Gas continues. Evaporate the new compound in a tolerably warm situation: very beautiful Rhomboidal Prismatic crystals of Phosphate of Soda will be formed. Dry them on blotting paper, and preserve them in a well stopped phial; as they effloresce by contact with the air.

CCCLIX.

TARTARIC ACID.

Dissolve eight ounces of pulverized Super-Tartrate of Potass in a quart of boiling water; when the whole is dissolved, add three ounces of finely powdered Carbonate of Lime, (chalk) until effervescence has ceased, stirring it frequently with a wooden spatula, or glass rod. An insoluble precipitate of Tartrate of Lime will be formed; this must be well washed with water, and the water poured off. Now pour in three ounces of Sulphuric Acid, diluted with two pounds, or pints, of water. Sulphate of Lime will be precipitated, and Tartaric Acid will be held in solution. Pour off the solution into a glass vessel, and evaporate three-fourths of the whole, by boiling. Pour the remainder into an evaporating dish for crystallization. The Crystals will be tabular and transparent.

CCCLX.

CITRIC ACID.

Squeeze several lemons into a bason, and add powdered chalk until effervescence ceases. This is caused by the escape of the Carbonic Acid Gas of the Chalk. Citrate of Lime will be deposited in the form of a white precipitate. The supernatant liquor is to be poured off, and the precipitate must be freed from mucilaginous matters by repeated washing. Now pour in some very diluted Sulphuric Acid, and place the whole for a few minutes over a lamp. Sulphate of Lime, a very insoluble salt, will occupy the bottom of the vessel, whilst the Citric Acid, being disengaged, remains in solution. Pour off the liquor, and evaporate gently by boiling; now set it aside to crystallize, which it will do in Rhomboidal Prisms. The Crystals will be pure Citric Acid, possessing a very sour but pleasant taste, and capable of combining with alkalies, earths, &c. This crystallized Acid is the same as that known by the name of Concrete Salt of Lemons.

CCCLXI.

CRYSTALLIZATION OF SULPHUR.

Melt some Sulphur in a deep crucible; when it has cooled so far that the upper surface is just hard, break off the bottom of the crucible with a hammer, and let the fluid Sulphur run out from beneath the crust. By this method, the crystallization in needles or slender fibres will be very evident. Preserve the specimen.

CCCLXII.

CRYSTALLIZATION OF TIN.

Melt four ounces of Tin in a clean crucible; when in a liquid state, immerse a thick iron wire in it, take it off the fire, and let it cool until a hardened covering be formed on the top, of the thickness of a halfpenny. Now withdraw the wire, and pour out through the aperture, all the fluid Tin beneath. When the crucible is quite cold, break it, and take out the hardened covering; it will be found in a crystallized state, and will exhibit a very beautiful appearance.

Observations. The crystallization of the surface of tin plates has, since its introduction into this country, been much in vogue, for the manufacture of small cabinets and other toys. It has been found, that when other metals are combined with the coating of these plates, the crystallization by the application of acids, will be much more perfect and beautiful. Accordingly, a patent has been taken out for manufacturing what are termed "*Amorphous Metal Plates,*" and in the specification, the Patentees express themselves thus:—

The metals that are found most convenient and proper for this purpose, are zinc, bismuth, copper, lead, and brass. The quantity of such metals to be added to the tin, to make the amorphous metal, and to produce the desired and certain effect of a pleasing, brilliant, and varied crystallization, is variable according to the degree or depth desired, and also according to the general character and crystalline figure and appearance which may from time to time be suited to the taste, caprice, and opinion of the public. The quality of the block-tin, as it may be more or less pure, will considerably influence the proportion of the alloy. It will also determine the particular metal or the combinations thereof, most proper for producing beautiful and brilliant crystals; much, too, will depend upon the nature of the heterogeneous substances, which are found to be more or less combined with the block-tin, as it comes from the smelter. It is therefore thought impracticable to lay down any fixed proportions for the mixture of the metals to be used in the composition of the amorphous metal; experience, attention, and the skill and judgment of the operator, must, under a due consideration of the existing circumstances, regulate it. *The proportions hitherto used have varied from the twentieth part, and upwards, of alloy, to each part of block-tin.* And the effect of an improved crystallization will be produced, whether such alloy be added to the tin, in the smelting of the block tin before coinage; or afterwards to the block, in the manner above described.

A character belongs to *meteoric iron* not generally known: this consists in the production of regular figures, and crystalline facets, on the polished surface of the iron, when moistened with nitric acid, analogous to those produced in the *moire metallique.*

CCCLXIII.

CRYSTALLIZATION OF BISMUTH.

Melt four ounces of Bismuth in a clean crucible, and proceed in all respects as in the last experiment. The Crystals will be formed in the shape of bundles of beautiful and brilliant plates. Preserve the specimens.

Observation. When melted copper is slowly cooled, it affords crystals in quadrangular pyramids, or in octahedrons.

CCCLXIV.

CRYSTALLIZATION OF MURIATE OF LEAD.

Melt four ounces of dry Muriate of Lead in a clean crucible, and set it aside to cool. When cold, break the crucible; this metallic salt will be seen, to have been converted into very beautiful opaque yellow Crystals, which should be preserved.

Observation. This salt when combined with one-fourth of very finely pulverized flint forms a beautiful glazing for pottery.

CCCLXV.

CRYSTALLIZATION OF CHLORINE GAS.

Fill a jar with Chlorine Gas, and surround it by snow, or pounded ice; or place it in a freezing mixture. The Gas will soon be condensed in small yellow Crystals on the sidesof the glass. A little elevation of temperature will now convert it into a substance of an oily consistence,—a further elevation will convert it into Gas as at first.

CCCLXVI.

INSTANTANEOUS CRYSTALLIZATION;

Or, the Effects of Atmospheric Air, and Agitation, on the cohesion of saline particles.

Into a small vessel containing about an ounce of boiling water, put as much Sulphate of Soda as will be dissolved, (that is, nearly an ounce and a half,) and pour the solution while hot into a phial previously warmed, (to prevent cracking,) which must be instantly corked air-tight. Let the solution cool, no phenomenon will take place; but if the cork be taken out, and the air admitted, a very beautiful but confused crystallization of the whole mass will immediately take place, accompanied by a slight evolution of Heat. It sometimes happens that the crystallization is rather tardy, from a superabundance of water: in this case, a crystal of the ready formed salt must be dropped into it; this will serve as a nucleus for the crystallization of the rest, which will immediately take place around it.—The same effect will take place by a slight agitation of the phial. This Experiment may be repeated, merely by putting the phial into a bason of hot water, until the crystals are melted, and then corking it as before; upon withdrawing the cork the same phenomenon will take place. This is a good instance of the influence of Atmospheric Air upon crystallization; for, before the cork was withdrawn, there was a vacuum in the phial.

Observations. It is certain, that no salt will crystallise without exposure to atmospheric air. Perhaps the atmospheric influence may be owing to a regular pressure, by which the particles of air are forced into the liquid, and thus the dense particles of the solution are brought together, forming crystals, whilst the air takes possession of the interstices. It would be well worth trial, whether saline solutions have the power of crystallizing in factitious atmospheres of the different gasses, either alone, or in combination. It would then be seen, whether the atmosphere has a *mechanical* or a *chemical* effect on crystallization.

We should not, owever, quit this subject without remarking, that some experiments of Doctor Ure render it probable that electrical influence has some agency in the phenomena under consideration. A glass tube was filled with a saturated solution of sulphate of soda; through a cork, at each end of the tube, a platinum wire was inserted, and the ends of the wire were exposed to the opposite electrical influence of a voltaic battery; hydrogen and oxygen gases were evolved from the oppositely electrified wires, more abundantly than from pure water with the same voltaic power; after a few seconds, crystallization appeared at the negative end of the tube, and proceeded steadily and slowly towards the positive end; the place of demarcation between the congealing and liquid parts being smooth and vertical. Different experiments of an analogous kind, as will presently be seen, presented similar general results.

Doctor Ure's object was to discover the power, or principle, which governed the formation of saline matter into crystalline masses. From the following experiments he draws a very probable inference, viz. that *agitation is the sole* cause of crystallization, but how far this is correct during the absence of the atmospheric pressure remains still to be proved; although he concludes, that neither *the chemical nor the mechanical effects of the surrounding air have any influence on crystallization.*

CCCLXVII.

An eight ounce phial filled with a saturated solution of Sulphate of Soda in boiling water, was cooled down to 38° Fahr. (the temperature of the apartment,) without crystallizing. The mouth of it was well secured with ox-bladder, which the pressure of the atmosphere had deeply hollowed on the contraction of the liquid volume by cold. The phial was placed under the receiver of an air-pump. When the Mercury in the two legs of the syphon gauge stood nearly on a level, the bladder became convex, though it had been strained flat across the orifice, when the phial was brimful of the boiling hot solution. On piercing the bladder with a sharp pointed rod, which passed air-tight through a collar of leathers in the top plate of the receiver; no change whatever took place; the point was then pushed down into the liquid without any further effect. To try the influence of vibratory agitation of the particles, *the handle of the air-pump was briskly moved backwards and forwards; when immediately, a portion of the solution was thrown out of the phial with an explosive effort, upon the receiver. The liquid instantly shot into a confused crystallization, and at the same time began to boil, from the heat evolved during solidification.* The temperature of the saline matter in the phial, when it was withdrawn at the end of a few minutes, was still 74°, though it must have lost much heat from the ebullition *in vacuo.*

The same experiment was tried a second time; and though no effect took place on piercing the bladder, yet on afterwards passing down the steel point into the liquid, crystallization, with the usual pearly appearance, commenced at the surface, and descended to the bottom. I believe, that in this case, the steel point at its first descent to puncture the bladder, had touched the liquid, and thus became *tipped with a little saline matter,* which drying rapidly *in vacuo,* served at the second plunge as a *nucleus* for crystallization.

CCCLXVIII.

The bladder was freely punctured *in vacuo* without effect; the air was slowly admitted into the receiver until it was of the atmospheric density. No change ensued at the end of two hours. The receiver was withdrawn, and the punctured hole enlarged by scissars without any result. But on *slightly shaking the phial* the liquid passed speedily into the solid state.

CCCLXIX.

The Sulphate was again liquified in the same phial, which was now closed with a perforated cork. Into this was fitted a glass tube, one-twentieth of an inch, internal diameter, and four inches long. As the tube passed only half way down through the cork, no liquid could enter it. After standing for fourteen hours exposed to the action of the external air,* through the tube, its liquidity was unimpaired. The glass tube was then withdrawn, and next, the cork, without any change ensuing; when finally, *on agitation,* it solidified.

CCCLXX.

A phial was nearly filled with a similar solution of Sulphate, on the surface of which was placed a little olive oil. It cooled without crystallizing. When *smartly agitated,* it became solid, with the usual phenomenon of the crystals shooting from the top downwards. This phial had been first placed on a vibrating glass plate, without effect. This experiment was repeated with a like result, though the phial stood two days.

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* Temperature of the apartment about 40 degrees, Fahr.

CCCLXXI.

A corked phial full of the hot solution was tied down to the plate of the air-pump, so that the cork could not be drawn *in vacuo* by a sliding steel rod and hooked extremity. When the cork was pulled, no change ensued; but *agitation* congealed the mass.

CCCLXXII.

The corked phial was cooled in a horizontal position; on inverting it quickly, the liquid struck against the glass, as in the water hammer. By brisk *agitation* in the inverted position, congelation began, first below, and ascended to the top of the liquid. This experiment was repeated, with the same result. No particle of air was left in the phial; a cork of the best quality being pressed on the surface of the liquid, and forced in, as the liquid contracted its volume, on immersing the phial into a basin of cold water.

CCCLXXIII.

A glass tube twelve inches long, and one inch in diameter, furnished with a brass cap and stop cock at one end, and a tight cork at the other, was filled with the hot solution. When it was cold, each end was opened, and the crystallization began instantly at the two extremities, and proceeded towards the middle.

CCCLXXIV.

The same tube filled and cooled, had a Platinum wire passing through the cork. On applying to each end, the opposite electrical influences of a Voltaic battery of 50 pairs of 4-inch plates, the *pearly crystallization commenced at the negative end*, and proceeded slowly to the positive, at which no symptoms of spontaneous congelation could be perceived. The Platinum wire was positive, and evolved Oxygen pretty copiously.

CCCLXXV.

A large egg-shaped vessel, holding about two pints, and terminated at each end by cylindrical apertures of one inch diameter, was filled with the hot saturated solution. Through the cork of each end was passed a Platinum wire. The vessel, after having been cooled in a bason of cold water to the temperature of 42°, was placed in a horizontal position, and the solution was subjected to the action of a battery of 60 pairs of 4-inch plates. From the oppositely electrified wires, Hydrogen and Oxygen gases were copiously evolved. The quantity of gas was much more abundant than I ever observed it from pure water with the same voltaic power. Hence, a saline solution affords a better medium for the popular exhibition of this fundamental Electro-chemical fact, than water alone. After a few seconds, *the pearly lustre appeared at the negative end of the vessel*, and the crystallization proceeded slowly and steadily towards the positive end, the place of demarcation between the congealing and liquid part being perfectly smooth and vertical. *No tendency to solidification was observed at the positive end*, though gas freely flowed from its Platinnm wire, during the whole time that the process of crystallization was advancing from the one extremity to the other.—This interval was about fifteen seconds.

CCCLXXVI.

The above Experiment was repeated in a small cylinder with tubular extremities. The negative wire projected internally, only to one half the length of the positive wire, in order to see whether it was merely the greater quantity of Hydrogen evolved, or some difference in the electrical properties, that determined the crystallization at the negative pole. Here again, as before, *the pearly appearance commenced at the negative extremity*, and proceeded beautifully towards the positive.

It was impossible now to doubt, that *there existed some relation between negative or resinous Electricity, and saline Crystallization.*

CCCLXXVII.

Two glass capsules were then taken. Into each an equal quantity of a tepid solution of pure nitre was put. They were placed alongside of each other, and the liquids were connected by a slip of clean filtering paper, moistened with pure water. The power of sixty pairs in moderate action was applied, through the medium of a Platinum wire dipped into the centre of each solution. In a short time, *small needles were seen collecting, and attaching themselves around the negative Platinum wire*, which soon increased so as to float through the whole liquid. After a much greater interval, a few crystals were perceived forming on the margin of the liquid in the positively electrified capsule, *but none near the immersed Platinum wire*. In equal times, the quantity of crystals in the negative capsule was quadruple of that in the positive capsule. There was found in the former a very slight excess of alkali, and in the latter, of acid, but such as in ordinary circumstances has no influence on the formation of crystals.

CCCLXXVIII.

A tin flask was filled with the same hot solution; and having its mouth secured with a slip of ox-bladder, it was suffered to cool. It was then placed on the top of a delicate condensing electroscope; and the bladder being pierced by a needle insulated at the end of a glass rod, no divergence of the gold leaves could be observed, even when both the large and small condensing plates had been folded back. I am not certain, that in this case, the liquid had remained uncrystallized till the instant of piercing the bladder. I shall repeat and vary the experiment, and from the elevation of temperature accompanying the solidification, I shall be able to ascertain whether the experiment has been successfully conducted, and whether any general inference can be drawn from it.

Observations. I think it probable from the above detail, that *negative electricity may be found a useful agent in promoting the crystallization of saline matter, and may perhaps be employed by Nature in her crystalline formations.*

The effect of mechanical disturbance in determining saline crystallization, is illustrated by the symmetrical disposition of particles of dust and iron by electricity and magnetism. Strew these upon any place, and present magnetic and electric forces at a certain distance from them; no effect will be produced. Communicate to the plane a vibratory movement: the particles at the instant of being liberated, from the friction of the surface, will arrange themselves according to the laws of their magnetic or electric attractions.

The water of solution in counteracting solidity, not only removes the particles to distances beyond the sphere of mutual attraction, but probably also inverts their attracting poles.—Hence, when they are again brought within the attracting limit, by abstracting water, or the repulsive caloric, some additional force is necessary to invert this liquid arrangement of the poles. It is thus that a crystal, brought into contact with the surface of the solution, may be conceived to act.

Experiments third, fourth and fifth, seem to prove, that neither the chemical properties of the atmosphere, nor its pressure, have any influence on crystallization.

CCLXXIX.

DISSECTION OF CRYSTALS;

Or their Structure discovered by Solution in Liquids.

Mr. Daniel has thrown much light upon the structure of solid bodies by the following method of experimenting :

If a lump of Alum, Borax, or Nitre, be immersed in water, for three or four weeks, the solution will be found to have gone on unequally. The uppermost portion will be found most wasted, and the undermost least; so that the undissolved parts will have assumed a conical form. The lower part will be found embossed over with numerous crystalline forms. These in Alum are Octahedrons, or figures formed by different sections of the aluminous Octahedron. In Borax, they are fragments of eight-sided prisms, and so on. Hence it follows, that all these masses are, in reality, composed of crystals, though such a structure cannot be distinguished by the eye, previous to this natural dissection. The same crystalline structure was developed when Carbonate of Lime, Carbonate of Strontian, and Carbonate of Barytes, were slowly acted on by vinegar. Bismuth, Antimony and Nickel, treated with very dilute Nitric Acid, likewise exhibited a crystalline structure.

Lime has been crystallized in six-sided prisms, by M. Gay Lussac.

Observations. The salts crystallized by art are numerous, but we must refer to the operations of nature, when we desire to behold these effects in their stupendous and magnificent forms. The different kinds of Basaltic rocks are proofs of this.

Basalt is a grey or greenish kind of stone, found in the neighbourhood of volcanoes, and near the sea. These stones have a regular angular shape, and ascend like groupes of pillars. Each pillar is formed of many crystals articulated to each other by joints ; that is, each joint is formed of concave and convex surfaces, one being inserted in the other. The Isle of Staffa, or Fingal's Cave, one of the Western Isles of Scotland, is a complete Basaltic rock of a grand and majestic appearance. The following drawing will give a tolerable idea of this natural wonder. There are several structures of the same kind on the coast of Argyleshire.

The Giant's Causeway in Ireland (of which, also, we have annexed a drawing,) is another stupendous natural fabric, of the most imposing aspect.

Some of its pillars are no less than five feet in breadth, and one hundred in height. They are supposed to have come from some volcano, (which has since disappeared) in the state of lava, and to have assumed the crystalline form on immersion in the sea. The materials of which Basaltes are composed, are Silica, Alumine, Oxide of Iron, Lime, Magnesia, Soda, and Muriatic Acid. Lava is composed of nearly the same materials, from which we may perhaps conclude, that the above theory of their origin is correct.

From a number of facts, M. Methuon conceives, " that *the natural process* of *crystallization*, originally, begins in a partial decomposition of the surface of a *crystallizable* fossil; that from certain spots of this surface, where it has first begun, the decomposition proceeds in straight and narrow lines to other similar spots; which in their turn send forth similar lines, sometimes parallel to the former, at other times crossing each other; thus dividing, or, more commonly speaking, carving or engraving the surface of the fossil into several compartments, which become, by a continuance of the process of decomposition, as many distinct pieces, constituting the body of the crystal in its rough state: and lastly, that during this process, the substances of a different nature, contained in the mineral, separate, and arrange themselves in one or more parts of the same compartment, the fossil mass continuing to be solid and hard, but fragile and easy to be broken." M. Methuon has often broken, between his fingers, some which had before withstood the strongest percussions.

M. Methuon maintains that he has proved: " 1st, That crystals begin to form at their summit, edges, and solid angles. 2dly, That nature produces, by a direct process, all simple and compound crystals, without first *forming* a *nucleus* in the centre. 2dly, That the *matter*, serving to form the crystals, is in the state of a solid mass before, and continues in that same state during the whole process of crystallization. It may be called *crystallizable* matter. 4thly, That *crystallizable* matter is that which has filled, by infiltration, the chasms and clefts of mountains, and the cavities of rocks; that which composes the veins, the stalactites, and the stalagmites; and, in general, all that, which constitutes accidental formations found in *blocks*, *nodules*, &c. within large masses.

He recommends for an artificial imitation of this natural crystalligenous process, " a bed one inch thick, composed of loose earth, obtained from the decomposition of the stone in which the crystallizable matter is found, having an elevated *brim* of the same material round it, one third of an inch in height. Some balls made of the same earth are disposed here and there, on this bed, on which are placed various pieces of solid *crystallizable* matter, formerly known under the name of *crystalline matrix*. On these pieces, other balls are properly disposed, serving to support some more specimens of crsytallizable matter, so arranged as not to touch each other. The whole of it is then made as solid as possible, by the addition of other large and small balls, introduced wherever any space exists; and lastly, the apparatus is surrounded by a wall of bricks laid singly on each other, without any mortar, and in a way to admit of a free circulation of air.

Every two or three days the whole apparatus is to be watered, so as to keep it in a state of constant humidity, and no more. A degree of temperature is maintained equal to the internal temperature of the earth; and the apparatus is examined every fortnight, or three weeks; when, if necessary, the pieces may be carefully washed and replaced, taking care to arrange them so, that the balls, which before were under, may now be placed above. After a certain lapse of time, the crystallizable matter is found to present distinct and beautiful crystals of the substances employed.

A Periodical Journal, in attempting to account for the diminution of the waters of the globe, has the following ingenious hypothesis: "Mountains having been conjectured to be formations from a state of solution in water, it has been enquired, "What has become of the vast body of fluid which formerly covered the earth, and stood over even the highest mountain peaks?" The following statement, it is presumed, may remove some of the difficulties attending this question. Salts, when crystallizing from a state of aqueous solution, are not confined to the surface of the liquid, but frequently rise above it. This effect being considerable on a small scale in our soda cisterns, how much more striking must it have been, during the crystallization of mountains! If crystals in a soda cistern shoot an inch above the surface of the solution, it cannot excite surprise; if in the vast primeval fluid, crystallizations have, in this way, risen many thousand feet above the level of the fluid. If this be admitted as a fair inference, it will go far in assisting us to explain what has been alled the diminution of the original waters of the Globe."

CCCLXXX.

CRYSTALLINE STRUCTURE OF FROZEN MERCURY.

Pour two or three drams of Mercury into a glass tube, and place it in a freezing mixture of two parts of Snow, or pounded Ice, and one of Muriate of Soda; this will reduce it to a little below Zero; take the tube from this mixture, and immerse it immediately in another, composed of four parts of Snow, and five of Muriate of Lime. The Mercury in the tube will be frozen into a solid mass of a crystalline structure. If the tube be broken, to extricate the mass, the solidity will be evident. Frozen Mercury is specifically heavier than Fluid Mercury, consequently it will sink in it.

CCCLXXXI.

LIQUIDS REDUCED BELOW THEIR FREEZING POINTS WITHOUT CRYSTALLIZATION.

It is well known that Liquids crystallize or freeze, when reduced to low temperatures; but this solidification may be in some cases considerably retarded. Expose a small quantity of distilled water to the action of freezing mixtures, first of small effect, and afterwards of greater; it will cool down to 22° without freezing; but if agitated, (not stirred) or if a small piece of ice be dropped into it, the water will immediately shoot out into crystals.

Observations. Dr. Brewster, when examining the optical phenomena of ice, found that even large masses, two or three inches thick, formed upon the surface of standing water, are as perfectly crystallized as rock crystal, or calcareous spar: all the axes of the elementary crystals corresponding with the axes of the hexaëdral prisms, being exactly parallel to each other, and perpendicular to the horizontal surface. This unexpected result was obtained, by transmitting polarised light through a plate of ice, in a direction perpendicular to its surface. A series of beautiful concentric coloured rings, with a dark rectangular cross passing through their centre, were thus exhibited; they were of an opposite nature to those which Dr. B. had before discovered in the beryl, ruby, and other minerals. The polarizing force of ice was found, from many experiments, to be [illegible] that of rock crystal being [illegible]

CCCLXXXII.

Pour three or four drams of Sulphuric Acid into a glass tube, and proceed in all respects as in the last Experiment. Although the freezing points of Sulphuric Acid, of various degrees of concentration, are several degrees above zero; still in this case, the Acid may be cooled down to 36 degrees below zero, before it begins to solidify; and even then, the mass will not exhibit a crystalline structure.

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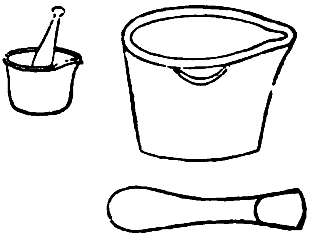
LIQUEFACTION OF SALTS BY TRITURATION.

It has been found, that Salts which decompose each other, when in solution, will do the same when triturated together. Thus it is evident, that the Water of crystallization, though in a solid state, has still the power to act as a solvent.

CCCLXXXIII.

SULPHATE OF SODA AND ACETATE OF LEAD.

Triturate together, in a Wedgewood's mortar, (see the annexed figures,) half an ounce of Sulphate of Soda with the same quantity of Acetate of Lead: they will combine, and be rendered fluid.



CCCLXXXIV.

SULPHATE OF SODA, AND NITRATE OF AMMONIA.

Put half an ounce of Sulphate of Soda, with the same quantity of Nitrate of Ammonia, into a Wedgewood's mortar, no action will take place; but if they be smartly rubbed together by the pestle, they will, both, part with their Water of crystallization, and this Water will render them both quite fluid.

CCCLXXXV.

MURIATE OF LIME, AND ACETATE OF LEAD.

Put half an ounce of Muriate of Lime, with the same quantity of Acetate of Lead, into a mortar: triturate them together. These Salts will part with their Water of crystallization, and be rendered fluid.

CCCLXXXVI.

MURIATE OF LIME, AND NITRATE OF SODA.

Triturate together in a mortar, half an ounce of Muriate of Lime, with the same quantity of Nitrate of Soda. These two substances will operate upon each other, and be rendered fluid.

CCCLXXXVII.

ACETATE OF LEAD, AND SULPHATE OF ZINC.

Triturate together, half an ounce of Acetate of Lead, with the same quantity of Sulphate of Zinc: they will combine, and be rendered fluid.

CCCLXXXVIII.

CITRIC ACID, AND CARBONATE OF POTASS.

Rub together in a mortar half an ounce of Citric Acid in crystals, with the same quantity of Carbonate of Potass; these substances will combine, and become fluid. The Citric Acid may be recovered, by saturating the Potass with Sulphuric Acid. Water poured over it, will form Solutions of Citric Acid and Sulphate of Potass; which will crystallize separately.

CCCLXXXIX.

Lime, and Oxalic Acid.

Put into a mortar, two drams of pure Lime, with two drams of Oxalic Acid: these substances, by trituration, will become fluid, from the Water of crystallization contained in the Oxalic Acid; and from the heat which they absorb, in the act of combination.

CCCXC.

Carbonate of Ammonia, and Sulphate of Copper.

Put three drams of Carbonate of Ammonia, and two of Sulphate of Copper, into a mortar; triturate them smartly; they will become fluid, and of a violet colour.

CCCXCI.

Action of Atmospheric Air on Deliquescent Salts.

Expose a few crystals of Muriate of Lime on a sheet of paper to the action of the air; in a very short time the crystals will be melted, or in other words, liquefied.

Observations. This is owing to the great affinity for water, which is one of the properties of this salt: it abstracts the moisture from the atmosphere. There are a great many salts more or less deliquescent; such as the nitrates of lime and magnesia, muriate of magnesia, &c.

Mr. Holdsworth, a gentleman who resided for three years in the higher latitudes of North America, lately communicated to the Editor of the Monthly Magazine, an account of some experiments which he had made on what he calls the *Absorption of Ice by the Atmosphere.* Mr. H.'s experiments were made on large blocks of ice, which having carefully weighed, he hung up in an out-house, when the temperature of the air was from 3° to 5°. The results of these experiments were, invariably, *a diminution in the weight and bulk of the blocks.* That this should take place in warm weather, and when the thermometer stands high, is not at all surprising; but that a diminution should take place under the above-mentioned circumstances, is certainly both novel and worthy of further investigation. Mr. Holdsworth concludes his interesting paper in the following words.

"Regarding the facts, however, as unquestionable, it must, I think, be evident, that the snow and ice in the arctic regions are continually undergoing a material diminution, by the constant operation of the cause mentioned. Instead of the gradual and perpetual accumulation of snow and ice which some have imagined to be constantly taking place in those regions, and rendering them inaccessible to mankind, we see a power continually at work, which must materially retard such an accumulation; and perhaps, when better understood, and when those regions shall be more perfectly explored, may be found adequate to prevent them altogether; or at least to prevent their acquiring a magnitude and weight, inconsistent perhaps with the general welfare and safety of the globe."

CCCXCII.

ON EFFLORESCENT SALTS.

Expose some crystals of Phosphate of Soda, on a sheet of paper, to the action of the air. They will in a short time be covered by a white powder. Thus, instead of absorbing moisture from the atmosphere, like the Deliquescent Salts, they impart their own moisture to it. If left long enough, the whole will be converted into a white powder; which is merely the saline matter deprived of its water of crystallization.

Observation. Sulphate, and carbonate of soda, sulphate of magnesia, &c. &c. are affected in like manner: viz. by efflorescence. There are many salts upon which the atmosphere exerts no action, such as muriate of soda, sulphate of potass, &c. &c. &c.

CHAPTER IX.

EXPERIMENTS ON THE DISCOVERY OF CERTAIN SUBSTANCES IN COMBINATION WITH OTHERS BY MEANS OF TESTS.

TESTS are substances which detect the presence of other substances in combination with any solvent, or known compound body. Their action depends on the affinity existing between the substance added, and any component part of the body under trial; whereby a new compound body is formed, differing essentially both from the Test and the body acted on.

CCCXCIII.

TURMERIC A GOOD TEST FOR ALKALIES.

If a few drops of Tincture of Turmeric are poured into any alkaline solution (of Potass, Soda or Ammonia,) the beautiful yellow colour of the Tincture will be converted to a deep brown.

Observations. As a more convenient test, a piece of paper, linen or cotton stained by tincture of turmeric (and kept dry for experiment) may be dipped in a solution of either soda, potass, or ammonia; on withdrawing the test paper, the part immersed will be brown instead of yellow. In any solution therefore where alkalies are suspected, turmeric is an excellent test. This test paper when dipped into an acid solution after the alkaline one, will recover its yellow colour by the neutralization of the alkali. Slips of this paper of half an inch in width should be kept ready folded in a sheet of writing paper. Preserving it thus will prevent its being exposed to ammoniacal vapour.

CCCXCIV.

LITMUS PAPER A TEST FOR ACIDS.

This paper is prepared in the same way as the Turmeric er, only that in this case, Tincture of Litmus is used.

It is an excellent test for the presence of all the acids except the Prussic. By these, its fine blue colour is invariably converted to deep red. To detect Carbonic Acid, proceed as follows.

Dissolve some Carbonate of Potass in water, and dip a piece of Litmus paper in the solution: it will assume a dark blue colour. If it be now withdrawn and held over the vessel, at the same time that Sulphuric Acid is dropped into it; the wetted part of the paper will be converted from *blue* to *red*. This change arises from the disengagement of the Carbonic, by the Sulphuric Acid, which seizing upon the Potass, drives the Carbonic Acid off with effervescence.

Observations. If a slip of the Litmus paper be dipped in any diluted acid (except the prussic) or into a solution supposed to contain an acid; or into any saline water containing an excess of acid over alkali, &c. the change from a blue to a red colour, will generally denote the quantity of uncombined acid which may be present. Slips of this paper, like the foregoing, should be kept ready folded up in paper.

CCCXCV.

PROOF BY TURMERIC PAPER THAT POTASSIUM IS THE *Base of Potass, and Sodium of Soda.*

Dip a half sheet of Turmeric paper in a bason of distilled water, and shake off the superfluous drops: spread it on a shallow plate and drop on it a large globule of Potassium, or Sodium. Either of these will immediately commence a rapid motion in all directions on the paper, staining it of a dark brown colour, in lines, as it moves along.

Observation. Here the potassium or sodium having a great affinity for oxygen, combines with it wherever it is to be found in a weaker state of affinity for any other substance, than for itself. In this case, the distilled water is decomposed, and its hydrogen set free:—the oxygen combining with the metal. The brown colour of the stains on the paper, is owing to the action of a new formed substance on the vegetable colouring matter of the turmeric. This new substance is the oxide of potassium, or sodium; or as they are usually called, potass or soda. Therefore potass or soda being alkalies have the characteristic effect of alkalies on this colouring matter.

CCCXCVI.

STARCH A TEST FOR IODINE.

Dissolve a dram of Starch in half a pint of water; add about five grains of Iodine in another half pint: on mixing the solutions, a beautiful blue colour will pervade the mixture, and in a short time a precipitate of the same colour will take place; which is Iodide of Starch. The blue colour is indicative of saturation; but if the starch prevails, it will have a violet hue, and if the Iodine is in excess, the colour will incline to black.

Observation. If in any liquid containing iodine be combined with another substance (besides water) it must be first set free, by adding to the liquid a few drops of sulphuric acid; and then pouring in the solution of starch. In this way, a half millionth part of iodine may be discovered in any liquid.

CCCXCVII.

SULPHURIC ACID AND BARYTES, TESTS FOR *Each other.*

Make a solution of twenty grains of Muriate of Barytes in more than half a wine-glass of pure water: dip the point of a straw into a phial containing Sulphuric Acid and immerse it in the wine glass. The whole liquid will become white like milk, this precipitate will soon fall to the bottom, being heavy and very insoluble.

Observations. Here the sulphuric acid suddenly seizes upon the barytes; forming sulphate of barytes; at the same time driving off the muriatic acid. The vapour of the latter may be indentified by holding the nose over the glass at the instant of decomposition. This experiment may be reversed by adding some of the solution of muriate of barytes to a glass of very diluted sulphuric acid.

CCCXCVIII.

TESTS FOR LIME.

Into any transparent liquid suspected to contain Lime, pour a few drops of a solution of Fluate of Ammonia: a plentiful white precipitate of Fluate of Lime (Derbyshire Spar) will fall down in the liquid.

CCCXCIX.

Pour into a solution of Lime in any acid, (Muriatic for example,) some of the solution of Oxalate of Ammonia: an immediate precipitation will take place of an insoluble salt: the Oxalate of Lime; Muriate of Ammonia will be held in solution.

Observation. It is more proper and convenient to use the oxalic acid in combination with ammonia, as this alkali serves to saturate the acid which has been just disengaged from the lime: otherwise this acid, if in excess, will redissolve the lime. Oxalate of potass also is an excellent test for lime.

CCCC.

WATER A TEST FOR SULPHATE OF LEAD
In Sulphuric Acid.

As Sulphuric Acid, in *the large way*, is made by combustion of Sulphur with Nitrate of Potass in leaden chambers, the superficial parts of the Lead are often dissolved by it; thus forming Sulphate of Lead, small portions of which are held in solution by the Acid, when sold in the shops. To detect this adulteration, pour a dram of the Acid into a tumbler of distilled water; if a white precipitate falls down, it is a proof of the presence of Lead. The affinity of water for Sulphuric Acid is the cause of this precipitation.

Observation. To purify sulphuric acid, the method we have just described is first necessary; the diluted acid should then be decanted from its impurities, and poured into a glass retort, where, by the heat of a sand-bath, it may be concentrated by expelling the water in the state of vapour.

CCCCI.

TEST FOR SULPHATE OF LIME IN SPRING AND RIVER *Waters, &c.*

Although Sulphate of Lime is so insoluble a salt, that an ounce of cold water will hardly dissolve one grain of it, still it is surprising, what quantities of it are held in solution in great bodies of water. To discover this salt, add to a tumbler of Thames, or New River water, a dram of the solution of Carbonate of Potass. An abundant precipitate of Carbonate of Lime will instantly take place. Here there is an instance of double decomposition: the Carbonic Acid combining with the Lime, and the Sulphuric Acid quitting the Lime for the Potass. The Carbonate of Lime being very insoluble is precipitated; and the Sulphate of Potass being soluble in water, remains in the clear liquid.

Observation. In analysing mineral waters, carbonate of potass is an excellent test, on account of this property of rendering them milky, if they contain sulphate of lime.

CCCCII.

GENERAL TEST FOR THE METALLIC SALTS.

Into any solution where a metal is suspected to exist in combination, pour a few drops of Prussiate of Potass: stir the mixture. If a precipitate falls down, it is a proof of the presence of some Metal, as this Salt has not the power of precipitating Salts, of which the earths form component parts. The colour and quantity of the precipitate will serve with the assistance of future tests, to demonstrate the name and nature of the Metal.

CCCCIII.

PRECIPITATION OF OXIDE OF IRON FROM THE *Carbonate, in Mineral Waters, by Lime Water.*

To any Mineral Water, suspected of containing Iron, add a little Lime Water: a precipitate of Carbonate of Lime, mixed with a portion of Oxide of Iron, which is of a light brown colour, will fall down.

CCCCIV.

TEST TO DISCOVER THE PRESENCE OF GOLD, *In Solution.*

Pour about ten or twelve drops of Nitro-Muriate of Gold into a wine glass containing distilled water; the mixture will in the present case be colourless, but if it be stirred round with a piece of tin, or a slip of tinned iron; it will assume the appearance of Port-wine. This precipitate, (which is the same as that known by the name of the *purple precipitate of Cassius,*) will soon fall down in the form of a purple powder.

CCCCV.

POTASS A TEST FOR PLATINUM.

Pour some of the solution of Carbonate of Potass into a wine glass, containing some diluted Nitro-Muriate of Platinum: a yellow precipitate will fall down.

Observation. As a solution of soda has not this effect; a very ready way of discovering the existence of potass in combination, is by letting fall a few drops of the nitro-muriate into the suspected solution.

CCCCVI.

TO SEPARATE ARSENIC AND IRON FROM SOLUTIONS *Of Nickel.*

Immerse a plate of Zinc in a solution of Nitrate of Nickel; it will be covered by a grey precipitate, which is a combination of Oxides of Iron and Arsenic.

Observation. This is a very excellent way of purifying solutions of this metal, as in its crude and metallic state, it is often combined with iron and arsenic. In these precipitations, the acid leaves the iron and arsenic, (but not the nickel) and combining with the zinc, deposits the oxides of these metals on the surface.

CCCCVII.

TEST FOR THE DISCOVERY OF IRON IN SOLUTION.

Pour a few drops of the solution of Succinate of Ammonia into a wine glass containing any fluid where Iron is suspected to exist; for example, a solution of the Muriate of Iron: there will instantly be a copious precipitate of Succinate of Iron, whilst Muriate of Ammonia will be held in solution. Chalybeate waters may thus be proved to have Iron in solution.

CCCCVIII.

TEST FOR THE PRESENCE OF IRON AND COPPER

In Alum.

Sulphate of Alumine and Potass, very often contains Sulphates of Iron and Copper. These may be detected as follows: dissolve two drams of the Alum in hot water, and pour the solution into different wine glasses, into one of these, pour a few drops of a solution of Prussiate of Potass; if Iron be present, a dark blue precipitate will take place; this is the Prussiate of Iron, or Prussian blue. Into the other glass pour a solution of pure Ammonia. If Copper be present, a beautiful light blue colour will pervade the liquid, from the precipitation of Ammoniuret of Copper.

CCCCIX.

PREPARATION OF PRUSSIATE OF AMMONIA AND OF IRON,

To be employed as a Reagent for Copper

The most sensible Reagents for Copper are without contradiction the Prussiates of Alkali and of Iron, particularly that of Ammonia. This Salt occasions in the Nitrate of Ammonia an abundant white precipitate, which is of a very beautiful red when, accidentally, an atom of Copper is found in the solution. To prepare this Prussiate, pour into a phial of the capacity of six ounces, three ounces of Caustic Ammonia, upon half an ounce of the finest and purest Prussian blue reduced to very fine powder. Stop the phial well, and leave the mixture to macerate in the cold for several days, taking care to shake it from time to time. If the deposited matter has become brown, add a new quantity of blue, and repeat this addition until the colour no longer changes. Filter the matter through paper, and pour by little and little on the residuum, an ounce of water, in order to separate all the salt. The filtered liquor is Prussiate of Ammonia and of Iron; it has a beautiful yellow colour and a particular odour.

This Prussiate is also the most sensible Reagent for Iron; it is even infinitely preferable to the Prussiate of Potass and of Iron.

CCCCX.

TESTS FOR TELLURIUM.

In a solution supposed to contain Tellurium, immerse a Tin rod. If Tellurium be present, it will be precipitated on the rod in the metallic state, it will have a greyish white lustre similar to the Tin itself. To prove beyond doubt the existence of the Tellurium in the solution, the precipitated metal should be wiped off from the rod by a feather on a piece of paper.

Observations. A further test for the presence of this metal, is a small quantity of the subcarbonate of potass, which will throw down a white precipitate. Experiments should be made with both these on different portions of the liquid to be tested.

CCCCXI.

TESTS FOR LEAD AND COPPER IN WINE, *Cyder, Perry, &c.*

Put into a crucible one ounce of Sulphur, and one ounce of pure Lime; and keep them in a white heat for nearly half an hour; when cold, add one ounce of the Super-Tartrate of Potass, and boil the whole in a mattrass with some distilled water for about half an hour. Decant the supernatant liquor into small phials, adding about twenty or thirty drops of Muriatic Acid to each. The phials must be well stopped and preserved for use. Lead, Copper and other deleterious metals will be precipitated, of a black colour, by this liquid, if poured, in the quantity of only a few drops, into the suspected Wine or Cyder.

Observation. The muriatic acid is added to this test, to prevent the precipitation of iron, which might exist in the wine without any mischief resulting from its use.

CCCCXII.

Another test for these pernicious metals in Wine and Cyder, exists ready formed in nature. Pour into a glass of suspected Wine, Cyder, or Perry, a few drops of Harrowgate, or Strathpeffer* water. If any lead, &c. be present, it will fall down in the state of a black precipitate, being combined with the Sulphurretted Hydrogen by which these waters are impregnated.

Observations. Lead is used by many wine-merchants to give an astringency to port-wine; that is, that like old port, it may appear rough to the tongue. Sometimes they hang a sheet of lead in the cask; at others they pour in a solution of acetate (sugar of) lead; for the purpose of sweetening, as they term it.

A noted London wine-merchant, acknowledged on his death-bed, that, in the long course of his extensive business, he had seen numbers of his customers fall victims to their predilection for his wines; and had remarked that no man ever lived long, who habitually drank them!!! Arsenic is used to give an oily appearance to sherry, madeira, and other pale wines.

If the Harrowgate water is used as a test, it will be proper, previously, to pour into the glass of wine, &c. a few drops of muriatic acid, to hold the iron in solution, as the sulphuretted hydrogen has not the power of taking it from this acid. A solution of iron may exist in the wine without the least detriment to the consumer.

CCCCXIII.

To DETECT ALUM IN RED WINE.

Add to the Wine a sufficient quantity of a strong solution of Chlorine in water, (Oxygenated Muriatic Acid) until it is changed to a yellow colour: let the precipitate, (composed of the Chlorine and the Vegeto-animal matter contained in the Wine,) which immediately forms, become settled, then filter the liquor, and evaporate it to one fourth of its volume; it will, now, in consequence of the presence of the Alum, have an astringent sweetish taste, and will furnish a *white* precipitate on the addition of Nitrate of Barytes, which is insoluble in water and in Nitric Acid. It will give a *yellowish-white* precipitate with pure potass, that is soluble on the addition of an excess of the potass; and a precipitate, of the same colour, with the Sub-

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* A very productive well in Rosshire, Scotland.

Carbonate of Soda, which is decomposed by the action of heat, into Carbonic Acid Gas and Alum, substances easily to be recognized by their characteristics.

CCCCXIV.

TESTS FOR THE PURITY OF THE ACETOUS AND *Acetic Acids.*

These Acids, from distillation in Lead and Copper vessels, very often contain Acetates of Lead, and Copper, in solution; and they are often willfully adulterated by Sulphuric Acid to encrease their Acidity. To detect these, pour into three wine-glasses some distilled Vinegar, (Acetous Acid,) or one dram of the Acetic Acid, diluted with three drams of distilled Water. Into one of these pour some Harrowgate water, (which contains Sulphuretted Hydrogen). If Lead be present in the Acid, a very sensible black precipitate will fall down. Into the second glass, pour a solution of pure Ammonia. If Copper be present the whole will immediately become light blue. Into the third pour a few drops of the solution of Muriate of Barytes; if the Acid contains Sulphuric Acid, the liquid in the glass will instantly become quite milky, from a precipitation of Sulphate of Barytes, which is a very insoluble salt.

CCCCXV.

TESTS TO DETERMINE THE PURITY OF SULPHURIC, *Or Nitric Ether.*

If any Ether will redden litmus paper, immersed in it, it is a proof that it contains superabundant acid, such as the Sulphuric, Acetic or Nitric; consequently the Ether cannot be pure. A superabundant portion of Sulphuric Acid in Sulphuric Ether, may be discovered by pouring a few drops of the solution of Muriate of Barytes into a dram of the Ether: if this be the case, a white precipitate will take place, which is the Sulphate of Barytes.

CCCCXVI.

TESTS TO DISCOVER THE PURITY OF NITRATE OF SILVER.

To a solution of Nitrate of Silver add a solution of the Muriate of Soda, here decomposition taking place on both sides, Nitrate of Soda and Muriate of Silver will be formed.

The latter of these will fall down in the state of a flocculent white precipitate.

But as this valuable salt is sometimes adulterated by Copper, it is proper to ascertain its purity, by pouring into a solution of it, in another glass, a solution of pure Ammonia. If Copper be present, it will be indicated by a light blue precipitate which will pervade the fluid.

CCCCXVII.

AMMONIACAL AND MURIATIC ACID GASES,

Tests for each other.

If a bottle containing Muriatic Acid, and another containing Water of Ammonia be brought together, with their mouths open, a white dense smoke will be seen to hover round them: this is Muriate of Ammonia, which is a solid substance, but formed by the union of two invisible vapours. If the bottles are opened apart, no vapour will be seen. When two jars, filled with these gases, are brought in contact, the effect is striking; but it is more so when Ammoniacal Gas is let up from the beak of a retort through Mercury into a jar half filled with Muriatic Acid Gas. Here, the Muriate of Ammonia will be seen deposited on the sides of the jar, in the form of beautiful needle-like crystals. From these experiments, it is evident that Ammonia, and Muriatic Acid-Gas, are good tests to discover each others presence in liquids.

CCCCXVIII.

SULPHUROUS ACID GAS AND AMMONIACAL GAS,

Tests for each other.

Open two phials, one containing Sulphurous Acid, and the other Water of Ammonia; and bring them near to each other. The vapours will combine, forming a white cloud, which presently will be precipitated on the glass in a solid state, forming *Sulphite of Ammonia.*

CCCCXIX.

NITRIC ACID A TEST FOR STEEL.

Let fall a single drop of Nitric Acid on any cutting or other instrument supposed to be Steel. If Steel, the part whereon the drop fell will immediately turn black. No effect will, for a considerable time take place, if Nitric Acid is dropped on pure

Iron. The blackening of the Steel is owing to the combination of its Iron with the Acid, and the consequent precipitation of the Carbon.

CCCCXX.

MODE OF DETECTING CHALK IN COMBINATION WITH *White Lead.*

White Oxide of Lead is often adulterated by the Carbonate of Lime: to detect this, pour over a dram of the suspected Oxide, four drams of pure Acetous Acid, This will dissolve both Oxide and Chalk, but if a few drops of a solution of Oxalic Acid be now poured in, a very abundant white precipitate of Oxalate of Lime will take place.

CCCCXXI.

TEST TO DISCOVER PURE SUB-MURIATE OF MERCURY *(Calomel) in Combination with another Powder; or to distinguish it from Pulverised Chalk, Plaster of Paris, &c.*

The specific gravity of Calomel is a very good test to distinguish it from other white powders, as it is much heavier than any of them: but the most unequivocal test is by rubbing some of the powder in a mortar with some pure Ammonia; or by shaking it in a phial with Lime-Water. In either of these cases, if the Sub-Muriate is present and in a pure state, the combination will become *intensely black.*

CCCCXXII.

SULPHURIC ACID A TEST FOR CARBONIC ACID.

Into any mineral, or other water, suspected to hold Carbonic Acid in solution, either alone or in combination with another substance; let fall one drop of Sulphuric Acid, at the same time stiring the liquid. A slight effervescence occasioned by the ascension of small globules of Carbonic Acid Gas will take place, if any of this Acid has been held in combination.

CCCCXXIII.

TESTS TO DETECT THE ADULTERATION OF *Essential Oils.*

Essential Oils are often adulterated by Alcohol, also by fixed and Essential Oils of cheaper price. To detect Alcohol, pour two drams of distilled water into a dram of the suspected Oil: the whole will become milky if Alcohol be present. To detect fixed Oils, as Almond and Olive Oil, let a drop of the suspected Oil fall on a piece of writing paper, and hold it near the fire: if the whole evaporates, and leaves no stain upon the paper, there is no fixed Oil present; but if a stain remains, that is, if the part where the drop fell appears greasy or transparent, the Essential Oil has been adulterated either by Almond, or by Olive Oil.

CCCCXXIV.

TESTS FOR THE METALS USED IN THE *Adulteration of Mercury.*

Dissolve a small quantity of the suspected Mercury in as much Nitric Acid as will saturate it, divide this solution in three wine glasses, and into the first pour some distilled water; if a white precipitate is thrown down, it is an indication of the presence of Bismuth. Into the second, pour water saturated with Sulphuretted Hydrogen Gas, and a brown precipitate will discover the presence of even the smallest quantity of Lead. Tin is known to exist in union with Mercury, by dropping in the third glass Nitro-Muriate of Gold, a little diluted, when a purple precipitate will take place.

CCCCXXV.

GALLIC ACID DETECTED IN THE ENGLISH OAK APPLE.

Pluck from an oak tree, one of those excrescences called *Oak Apple*, and whilst fresh, cut it in two, by a table or pen-knife. Let the moisture dry upon the blade, and on inspection it will be found covered with a black fluid, in every respect like Writing Ink. If the apple be examined, a like appearance may be observed on each of the cut surfaces.

Observation. In this experiment, the gallic acid, existing plentifully in the apple, combines with the iron, forming gallate of iron.

CCCCXXVI.

GENERAL TESTS FOR VOLATILE ACIDS.

If a liquid is suspected to contain any uncombined volatile Acid, such as the Sulphurous, Nitrous, Muriatic, Carbonic or Acetic, it is merely necessary to hold over the vessel containing it, a slip of paper previously dipped in liquid Ammonia. If any of these Acids exist in the solution, their Gaseous or volatile particles will combine with the vapour of the Ammonia, and form a solid salt.

CCCCXXVII.

TEST FOR THE DISCOVERY OF CHALK IN THE *Adulteration of Magnesia.*

On account of adding to its weight, Magnesia is very often adulterated by Chalk. To discover this imposition, put some Carbonate of Magnesia into a tumbler, and pour over it some diluted Sulphuric Acid as long as a discharge of Carbonic Acid Gas, by effervescence, takes place. If the whole is now quite limpid, and no white powder remains, the Magnesia has been free from adulteration, but if this be the case, it has been adulterated by powdered Chalk.

CCCCXXVIII.

TO ASCERTAIN THE PURITY OF BLACK *Sulphuret of Mercury.*

For fraudulent purposes, this article is very often adulterated by Ivory black: and to detect the imposition, nothing more is necessary than to put about a dram of it on a shovel and to hold it over the fire; if the Sulphuret is pure, the whole will be volatilised, if not, Ivory black is present. To ascertain whether the Mercury and Sulphur are properly combined, rub a small quantity on a piece of Gold; and if the Gold be whitened like Silver on the part rubbed, the Mercury is not properly combined, but exists in the state of very minute globules. If, on the contrary, it leaves no mark, it is well combined with the Sulphur. The white stain is caused by the affinity existing between Gold and Mercury.

CCCCXXIX.

TESTS TO DETECT SUBSTANCES USED IN THE *Adulteration of Vermilion.*

Red Sulphuret of Mercury, or Vermilion, is often adulterated by red oxide of Lead, Chalk, and a substance known by the name of Dragon's blood. To detect these, put a small portion of the Vermilion into three wine glasses; into one of these pour a little alcohol; if Dragon's blood exist in it, the Alcohol will be slightly tinged of a red colour. In a few days, if shaken in a phial, it will be quite red, or if held over a lamp in a florence flask, the Alcohol will soon acquire a deep colour.

Into another of the glasses pour some pure Acetous Acid, if Chalk be present, effervescence will be the consequence; but as a further test, pour the clear liquid into another glass, and add a solution of Oxalic Acid: in this case, a white precipitate of Oxalate of Lime will fall down. To detect red Lead, pour some Acetous Acid into the third glass and decant the liquor: into this pour some Harrowgate water; if Lead exists in it, a black precipitate will fall down. A further test for Lead, is a solution of the Sulphate of Soda; this will cause a white precipitate of Sulphate of Lead.

CCCCXXX.

PROOF OF THE EXISTENCE OF HYDROGEN IN SULPHUR.

Sir H. Davy proved the existence of Hydrogen in Sulphur, as follows:—a bent glass tube, having a Platinum wire hermetically sealed into its upper extremity, was filled with Sulphur. This was melted by heat, and a proper connection being made with the Voltaic Apparatus of five hundred double plates, each six inches square, and highly charged, a most intense action took place. A very brilliant light was emitted; the Sulphur soon entered into ebullition; elastic matter was evolved in great quantities; and the Sulphur from being of a pure yellow, became of a dark reddish brown tint. The Gas was found to be Sulphuretted Hydrogen, or Hydrogen Gas holding Sulphur in solution; and its quantity, in about two hours, was more than five times the volume of the Sulphur employed.

CCCCXXXI.

SOLVENT FOR SILVER; AND TESTS FOR ITS *Adulteration by other Metals.*

Dissolve an ounce of Nitrate of Potass in eight ounces of Sulphuric Acid, in a glass vessel over a lamp, and put into it several pieces of impure silver, or suspected coin. When the liquid arrives at the temperature of 220°, the Silver will be acted on by (what may be termed) the Nitro-Sulphuric Acid: this action will be attended by an evolution of Nitrous Gas.

Observation. The best property of this solvent, is, that it does not act on any other metal than the silver: consequently if base silver coin be held with a forceps in this hot acid, it will be quickly stripped of its silvery coat, and the copper, &c. will be exposed to view. This compound acid is also useful in the large way, in extracting pure silver from old plated goods, as the copper, &c. cannot be acted on.

CCCCXXXII.

TESTS FOR GUM IN SOLUTION.

Pour into a solution of Gum Arabic, a little of the solution of Acetate of Lead; a very flocculent precipitate will fall down, composed of Gum and Oxide of Lead. Here the Acetic Acid quits the Lead to combine with the water, consequently the Oxide falls down with the Gum.

CCCCXXXIII.

TESTS FOR THE PRESENCE OF TITANIUM.

Pour a little of the Muriate of Titanium into three wine glasses: into one pour a solution of Carbonate of Potass, a *white* precipitate will fall down. Immerse a piece of Zinc in the other glass; a *blue* colour will be produced. If a Tin rod is immersed in the third glass, the colour will change to a beautiful *red*.

CCCCXXXIV.

TESTS OF THE PURITY OF NITRIC ACID.

In manufacturing Nitric Acid in the large way, it is often adulterated by Muriatic and Sulphuric Acids. To separate from it the latter of these substances, pour in a solution of Nitrate of Barytes, as long as a precipitate of Sulphate of Barytes falls down. Now pour off the Acid into another vessel, and add to it a solution of Nitrate of Lead, made with boiling water; a precipitate of Muriate of Lead will accordingly fall down. When this has settled, pour off the clear liquid into a retort and distil to expel the water which was necessarily combined with the precipitants, for their solution.

Observation. To preserve this acid from decomposition, it should if in a clear glass bottle, be kept in a dark place.

CCCCXXXV.

TEST OF THE PURITY OF CHLORIC ACID

Pour some Chloric Acid, (obtained from Chlorate of Barytes and Sulphuric Acid) into two wine glasses. Into one of these pour some diluted Sulphuric Acid, if a white precipitate falls down, it is a proof of its being adulterated by Barytes; this precipitate being Sulphate of Barytes. To the other glass add a solution of Chlorate of Barytes, if a white precipitate should here fall down, it is a proof that an excess of Sulphuric Acid has been added in the formation of the Chloric Acid; consequently, the latter is far from being pure. The White precipitate afforded by the latter test, is also Sulphate of Barytes.

CCCCXXXVI

TESTS FOR LEAD, ARSENIC, AND CHALK,

When white Oxide of Zinc is supposed to be adulterated by them.

The two first of these adulterations may be accidental: the latter is wilfully done for fraudulent purposes. To detect the Arsenic and Lead, put some of the suspected powder into a tumbler, and pour over it pure Acetous Acid, (distilled Vinegar) decant the solution into another tumbler, and pour in some Harrowgate water. If Lead be present, the Sulphuretted Hydrogen of this test will turn it black, and a precipitate of that colour will accordingly fall down. If Arsenic be contained in it, the precipitate will be yellow. In case that both these should be present, it will be proper to examine the precipitate after decantation of the supernatant liquid. To discover the presence of Chalk;—when Acetous Acid is poured over it, an effervescence of Carbonic Acid Gas will take place; but as a farther proof, add a solution of Oxalic Acid to the Acetous solution: an insoluble white precipitate of Oxalate of Lime will instantly fall down.

CCCCXXXVII.

PROOF OF THE EXISTENCE OF CARBONIC ACID GAS

In the Atmosphere.

Take a pencil of pure potass from the phial in which it is kept, and place it on a saucer in the open air. In a very short time, it will swell, and at the extremities will branch out like a cauliflower. Leave it undisturbed until it crumbles and falls to powder; if the Atmosphere be moist, the moisture, as well as the Carbonic Acid will be attracted. Now collect the Potass, and put it into a small tubulated retort: pour over it three or four drams of diluted Sulphuric Acid; effervescence will be the consequence, and a Gas will come over which may be received in a jar over Mercury or water. This Gas is Carbonic Acid, imbibed by the Potass from the Atmosphere. The certainty of its being so, was proved by the effervescence which took place upon adding the Sulphuric Acid; it may be further proved by its inability to support combustion or animal life; also by reddening wet litmus paper immersed in it; and likewise by rendering Lime water turbid, when agitated with it. That no Carbonic Acid existed previously in the Potass, may be proved, by pouring an Acid over it in its pure state.

CCCCXXXVIII.

SULPHUROUS ACID GAS A TEST FOR WATER HELD IN *Solution in the Atmosphere.*

Sulphurous Acid Gas received over Mercury is an invisible Aerial body; but if a phial containing this Gas be opened, an immediate cloud of vapour will be seen hovering over it. This is caused by the ascent of the Gas, and the great affinity it has for moisture: this it finds in the air, in the state of vapour from water, and with this vapour it immediately combines, forming a dense cloud.

CCCCXXXIX.

SEPARATION OF CARBON FROM THE CARBONIC ACID, *Existing in Carbonate of Lime.*

Proceed in all respects as in Experiment 211, where the process for preparing Phosphuret of Lime is detailed; but instead of using pure Lime, use dry Carbonate of Lime, (Chalk). When the tube is emptied, a black powder, which is pure charcoal, will be found diffused amongst its contents.

Observations. In this experiment, the carbonate of lime, by being heated to redness, is decomposed, and the carbonic acid is ready to fly off in a gaseous form; but it is arrested in its progress by the phosphorus (at this moment sublimed) which robs it of its oxygen, and leaves the carbon free to be precipitated among the lime. The phosphorus is thus converted into phosphoric acid, and finding the lime disengaged, it unites with it, forming phosphate of lime.

CCCCXL.

MURIATE OF TIN A TEST FOR TANNIN.

As it is of importance in many cases to ascertain the existence of Tannin, or the astringent principle in Vegetable infusions, the following may be depended on as a delicate test. Pour a few drops of the solution of Muriate of Tin into a wine glass containing an infusion of Gall-nuts, or of Peruvian, or Oak Bark. This salt will form an insoluble precipitate with the Tannin, contained in each of these.

CCCCXLI.

GELATINE AND TANNIN TESTS FOR EACH OTHER.

When Tannin is suspected to exist in any vegetable, make a decoction or infusion of it; and into half a wine glass full, drop some solution of Isinglass, Size, Glue, or, animal Gelatine obtained by boiling calves feet, &c. If Tannin exists in the infusion or decoction, a white or yellowish flocculent precipitate will instantly take place. The most ready experiment of this kind will be to add a few drops of the solution of Size to an infusion of Galls, Oak bark, or Peruvian bark, when the effect will be very satisfactory. On the other hand, an infusion of Galls or Oak bark will discover the presence of Gelatine, in any mixture where it may exist. In all effects of this kind, the Tannin by its astringent power, brings the Gelatinous particles into closer contact, and thus coagulating, they are precipitated. It is on this principle that leather is tanned, the raw hides contain Gelatine, and the Oak bark tannin; and when the hides are immersed in pits containing the Bark liquor, their fibres are brought into closer contact, and of course their texture is thus rendered tougher and stronger.

CCCCXLII.

DETECTION OF ARSENIC BY THE NITRATE OF SILVER.

Into a clean Florence flask, introduce two or three grains of white Arsenic, to which add about eight ounces of rain or distilled water, and heat the solution until it boils. Frequently shake the flask, and add to the hot solution, a grain or two of Sub-Carbonate of Potass, agitating the whole to make the mixture uniform. Pour into a wine glass, about two table spoonfuls of this solution, and touch the solution with a piece of fused Nitrate of Silver, a beautiful yellow colour will instantly take place at the point of contact, and proceed towards the bottom of the glass as a flocculent and copious precipitate.

Observations. The validity of this test, in its application to fluids only suspected to contain arsenic, has been questioned on the following grounds. 1st. Because *the alkaline phosphates are found to produce precipitates with silver, analagous in colour and appearance to the arseniate of silver.* This objection may be obviated by the following means; drop the fluid containing, or supposed to contain, the arsenic, (prepared as in the above experiment,) on a piece of white paper, making with it a broad line; along this line a piece of lunar caustic (fused nitrate of silver,) is to be slowly drawn several times successively, when a streak is produced of a colour resembling that commonly known by the name of *Indian Yellow*; this is equally produced by the presence of arsenic and of the alkaline phosphates; but a distinctive change soon takes place, for the yellow from the alkaline phosphates, turns, in less than two minutes, to a dull green, and becomes gradually darker, and ultimately quite black. The arsenical yellow, on the other hand, remains permanent, or nearly so, for some time, when it becomes brown. In performing this experiment, the sunshine should be avoided, or the transitions of the colour will take place too rapidly to be accurately observed. 2nd. Because *the muriates produce precipitates in the silver, so flocculent, as to overcome every indication which the presence of arsenic would otherwise afford.* To obviate this difficulty, we should add to the fluid to be examined, diluted nitric acid, and cautiously apply the nitrate of silver until the precipitation ceases; in this way the muriatic acid will be entirely removed, whilst the arsenic, if it be present, will remain in solution, and may be rendered evident by the affusion of ammonia, which will instantly produce the yellow precipitate in its characteristic form.

When arsenic is contained in a solution, in which an alkali is not present, it may be detected by the ammoniaco-nitrate of silver, a test proposed by Mr. Hume, under the characteristic form above designated.

CCCCXLIII.

ARSENIC DETECTED BY THE SULPHATE OF COPPER.

Prepare a solution of White Arsenic and Sub-Carbonate of Potass, as in the last experiment, drop into the liquor a small quantity of a solution of Sulphate of Copper; a bright yellowish green precipitate, termed *Scheele's green*, will be instantly produced.

Observation. An ammoniacal sulphate of copper may be used, as in the last experiment, when a solution contains arsenic without the presence of potass.

CCCCXLIV.

ARSENIC DETECTED BY REDUCTION

To the Metallic State.

Mix a portion of White Arsenic with equal quantities of finely powdered Charcoal, and twice as much dry Carbonate of Potass, put the mixture between two polished plates of Copper, bind them tightly together by Iron wire, and expose them to a low red heat; a white stain will appear on the surface of the Copper, which is an alloy of the two metals.

CCCCXLV.

ANOTHER MODE OF REDUCTION.

Put some of the foregoing compound of Arsenic, Charcoal, and Potass, into a small dry glass tube, eight or twelve inches long, sealed at one end, and place in the mouth of it a loose paper stopper. After gradually warming this tube, place it in a chaffing dish of red-hot Charcoal. The Oxygen of the Arsenic combines with the flux and leaves the metal free to be sublimed by the heat. It will accordingly be found to adhere to the internal surface of the upper part of the tube in a brilliant metallic state. When the process of sublimation is finished, and the tube is cold, withdraw the stopper, and with the point of a knife scrape off the metal from the inside; place this on a clean hot fire-shovel; if the metal be Arsenic, it will sublime, giving out white mes, which smell strongly like garlic.

CCCCXLVI.

Iodine and Starch,

Tests for Arsenic, and Corrosive Sublimate.

The following method has been proposed by Brugnatelli, for discovering Arsenic and Corrosive Sublimate in their respective solutions, and to distinguish them from each other. We must take the starch of wheat boiled in water, until it is of a proper consistence, (and recently prepared;) to this is to be added a sufficient quantity of Iodine until it is of a blue colour; it is afterwards to be diluted with pure water, until it becomes of a beautiful azure blue.——If to this azure coloured solution of starch we add some drops of an aqueous solution of the Oxide of Arsenic, the colour changes to a redish hue, and finally is quite dissipated. The solution of Corrosive Sublimate, poured into the Iodine and Starch, produces in it almost the same change with the Arsenic; but if, to the fluid, discoloured by the Oxide of Arsenic, we add some drops of Sulphuric Acid, the original blue colour is restored with more than its original brilliancy; whilst the colour of the fluid that has been discharged, by the corrosive sublimate, cannot be restored, either by the Sulphuric Acid, or by any other means.

CCCCXLVII.

Arsenic detected by Sulphuretted Hydrogen.

Into any solution suspected to contain Arsenic, pour some water impregnated by Sulphuretted Hydrogen Gas: if Arsenic be present, a yellow precipitate of Sulphuret of Arsenic will fall down. This will take place sooner by adding a few drops of Acetic Acid. But this test is not altogether to be relied on, as other metals may be precipitated of the same colour.

CCCCXLVIII.

By Prussiate of Potass.

If, however, to another portion of the solution, a little Prussiate of Potass be added, and if the precipitate be white; the presumption that Arsenic exists in the solution, is certainly very strong.

CCCCXLIX.

Tests to detect the presence of Oxy-Muriate *of Mercury (Corrosive Sublimate).*

Expose the suspected substance to heat, in a tube, as directed in the Experiment 445, but without any carbonaceous mixture, the corrosive Sublimate will rise in fumes and line the interior surface of the tube with a shining white crust. This crust is then to be dissolved in distilled water, and assayed by the following tests. First *Lime-Water* will produce a precipitate of an orange yellow colour. Second, a single drop of a dilute solution of *Sub-Carbonate of Potass* will at first produce a white precipitate, but on a still further addition of the test, an orange coloured sediment will be formed. Thirdly, water holding in solution *Sulphuretted Hydrogen*, will throw down a dark coloured precipitate, which when dried, and strongly heated, may be volatilized without any odour of garlic being manifested. (See also the test with Iodine and Starch, Experiment 446.)

Observations. Much difficulty has often been experienced in detecting the mineral substances which act as poisons, especially, corrosive sublimate, arsenic, copper, lead, and bismuth; when they have been mingled, in the stomach, with coloured liquids, such as red wine and coffee, a circumstance which not unfrequently happens in cases of poisoning by those minerals. This difficulty has arisen from the colour of red-wine or coffee, changing that of the precipitates obtained by the tests above designated. A method has very recently been discovered by Orfila by which these inconveniences may be obviated. The process consists in first discolouring or bleaching the liquid to be examined, by means of a concentrated solution of chlorine in water (strong oxygenated muriatic acid,) then applying the proper tests in the ordinary way. As the solution of chlorine decomposes but a very few of the mineral poisons, there are hardly any of them to which this method is not applicable. Nitrate of silver and tartarized antimony are the only exceptions likely to occur in medical practice.

We shall here detail some further experiments, to elucidate more clearly this important subject. Some white oxide of arsenic was dissolved in water and mingled with red wine, a sufficient quantity of a concentrated solution of chlorine was added to change the mixture to a yellow colour; a yellowish-red precipitate formed, composed of chlorine and the glutinous matter contained in the wine; when this precipitate had settled, the liquor was filtered; in this, lime-water produced a *white*, ammoniacal sulphate of copper a *green*, and sulphuric acid a *yellow*, precipitate. The same results were obtained from a mixture of coffee with white arsenic. Corrosive sublimate treated in the same way, was precipitated of a *yellow* colour by potass, *white* by liquid ammonia, and *black* by sulphuretted hydrogen. Sulphate of copper and verdigris, submitted to the same process, furnished a brownish precipitate with the prussiate of potass, green with the arseniate of potass, and black with the hydro-sulphurets. Litharge and acetate of lead treated in a similar way, gave rise to white precipitates with the sulphate of potass, black with the hydro-sulphurets, and bright yellow with the chromate of potass. If some of the foregoing mixtures are too much diluted when the tests are applied, no precipitates will be produced; it will, in some cases, be necessary to evaporate them previously to the addition of the chlorine to one half or one quarter, or less, of their volume; when the desired effects will be produced.

CCCCL.

TO DETERMINE WHETHER A MINERAL CONTAINS LEAD.

Break a small portion from the Ore, and observe the fragments and their brilliancy; now place a bit not larger than a pepper-corn on a piece of charcoal, then with the blow-pipe, blow through the flame of a candle, directing the jet upon the mineral. If it contains Lead, it will instantly discharge sulphureous vapours, and in half a minute, the Lead will be reduced.

Observation. The ores of this metal are numerous; the most common is blue lead ore, which occurs in great quantity, and from it the lead in commerce is produced. Others are of various colours, as grey, green, brown, yellow and red.

CCCCLI.

TO DETECT MERCURY IN MINERALS.

Earths or Minerals of any kind, containing Mercury, are most accurately assayed by distilling them with Iron-filings; but whether a mineral contains Mercury or not, may be easily discovered, by strewing it, when powdered, on a plate of hot Iron, or on a hot brick covered with Iron-filings, and inverting over it a glass of any kind; the Mercury, if the mineral contains any, will ascend, and attach itself in small globules to the sides of the glass.

Observations. Mercury is found both in the native state; and as an ore, combined with sulphur, &c. Native mercury is called living or running mercury, because it is seen to run in small streams at the bottoms of some mines. It is more frequently, however, imbedded in calcareous earths, or clays of different colours, from which it may be separated either by trituration and lotion, (the smaller globules coalescing by mutual contact into larger;) or by distillation. Cinnabar is the most common ore of mercury; it is found in an earthy form, resembling red ochre, sometimes in an indurated state, and, though generally red, it has been observed of a yellowish or blackish cast; it is mostly opaque, but some pieces are as transparent as a ruby. This ore consists of mercury and sulphur combined together in different proportions; some cinnabars yielding as much as seven, others not three parts, in eight, of their weight of mercury. Sulphur and mercury, being both volatile in a small degree of heat, would rise together in distillation, unless some substance, such as quick-lime or iron-filings, was added to the cinnabar, which by superior affinity, can unite itself with, and detain the sulphur: whilst the mercury, not being able to support the heat, is elevated in vapour, and condensed in various ways in different works.

CCCCLII.

To detect Gold in Minerals.

Scrape the mass with the point of a knife; it it be Gold, it will be soft and may be cut like lead: or strike it gently with the small end of a hammer, if it be Gold, it will be indented. Melt a small particle with the blow-pipe, if it be Gold, its colour will remain the same; but if it be brittle and hard to the knife and hammer, it is not Gold. Place a few fragments upon a hot shovel, or under the flame of the blow-pipe, if the Sulphur burn away, leaving scoria that is attracted by the magnet; this proves that it is a combination of Sulphur and Iron, commonly called Iron Pyrites. Put a few of the particles into a watch-glass, and drop a little Muriatic Acid upon it, and hold it over the flame of a lamp or candle until it boils, if it is Gold, no alteration will take place; but if not, effervescence and change of colour will be the result, which shews that the substance is acted upon by the acid; the contents may now be thrown into a glass of water, into which let fall a few drops of Prussiate of Potass, the liquid will change to a beautiful blue. The Iron of Pyrites being dissolved by the acid, will be thrown down in the state of Prussian Blue.

CCCCLIII.

Examination of Silver Ores.

A rich Ore will be soft to the knife or hammer, and melt under the blow-pipe with little difficulty; and by repeated fusion with borax, a bead of Silver may be produced.

A few small particles of the Ore may be put into a watch-glass, into which drop a little Nitrous Acid; then hold it over the flame until it is dissolved. After this dilute it with water, and stir it about, with a bright Copper wire; if any Silver is present, it will precipitate upon the Copper, covering it with Silver. Or add a little table salt to the solution; a white cloud of Muriate of Silver will fall down

Observation. Native silver occurs in delicate curled fires of a whitish colour in the cavities of Quartz; and often, surrounded by a black earthy substance. Sometimes these fibres are retinated, or cross each other. This silver is oftentimes very brilliant and pure; when tried by the knife, it will be found harder than Lead. It may be distinguished from tin, by being heavier, and by not crackling as tin does, when bent.

CCCLIV.

To discover Copper Ore in Minerals.

Place a small piece of supposed Copper Ore upon a piece of Charcoal, with a little powdered Borate of Soda, (Borax,) and direct the flame of a blow-pipe upon it. If it be rich Ore, it will be reduced to a bead of pure Copper, colouring the slag green, or reddish brown; it is sometimes necessary to repeat the fusion. Another method of detecting Copper is as follows:

Reduce a small particle to powder; put it into a watch glass, with a few drops of Nitrous Acid; if no action takes place, apply a little heat, by holding it over the flame of a lamp; the Copper will soon be acted upon, and dissolved by the caid Now add a few drops of water, and stir it with the point of a knife, or any piece of clean Iron. The Copper will leave its solution, and precipitate upon the Iron, covering it, and giving it the appearance of Copper. Or the contents of the watch-glass may be thrown into a glass of water; to this add a few drops of liquid ammonia, and it will become of a beautiful blue colour.

Observation. Ores of copper have commonly a yellowish brown appearance, the poorer ores much resembling pyrites, but they are softer to the knife. Copper ores, that are richer, are of a gold yellow: some are irridescent, exhibiting a pretty and variable display of colour, and are called peacock copper:—others are green, and in delicate fibres; sometimes compact, beautifully zoned, exhibiting great variety of lighter and darker shades; these are called malachite. Copper ores are sometimes too, of a green, black or red colour. Native copper is often found in veins in Cornwall.

CCCLV.

Analysis of the Ore of Tin.

The Ores of this metal may, after having been pulverized, and mixed with Borax, be reduced to the metallic state; but care must be taken not to continue the heat too long, as it will burn away: a little soot, or soap, melted with it, will assist the operation. If this test is insufficient, the Ore may be dissolved in a little Nitro-Muriatic Acid, and precipitated of a yellow colour, by pouring into the solution a little pure Potass.

Observation. Tin ores may be known by their comparatively great weight; they are crystallized, and sometimes of a resinous colour, but commonly approaching to black: tin also occurs in small massive striated pieces, called *wood tin.*

CCCCLVI.

TO DETECT MANGANESE IN MINERALS.

Exposed to the flame of the blow-pipe, with Borax, a purple glass is produced. Manganese may also be known by putting a little Muriatic Acid to a small quantity of the powder, and by holding a piece of wet printed cotton, &c. over the fumes; the colour will be destroyed: also by immersing a piece of coloured cotton, which will be bleached by the solution.

Observation. Manganese has many varieties, and is distributed in great abundance. It may be known by its earthy appearance, and is commonly called *black wad:* this mineral contains fibres imbedded in it, of a metallic lustre. Other varieties are composed of acicular fibres, sometimes aggregated, and have an iron-like splendour. It is very frequent in Devonshire, and when examined, may easily be distinguished from iron, or any other substance.

CCCCLVII.

TESTS FOR IRON ORES

Iron may be detected by placing a small particle of Iron Ore under the flame of the blow-pipe; it will not melt, but after it has been kept red-hot a few seconds, the Magnet attracts it. Or reduce the particles to powder, put them into a watch-glass, and add a drop or two of Sulphuric Acid, hold the glass over the flame of a lamp. When perfectly dissolved, throw the whole into a glass of water, to which add a few drops of Tincture of Galls. The product will be Ink. If Prussiate of Potass be added to another portion, Prussiate of Iron (Prussian blue) will be precipitated. This will be distinguished by its blue colour.

Observation. The common iron ore of England, is what is called clay [illegible]. It is almost always found near coal, which is so necessary [illegible] to the metallic state.

CCCCLVIII.

COAGULATION OF OLIVE OIL, A TEST FOR ITS PURITY.

This phenomenon takes place, when a small quantity of the solution of Acid per-nitrate of Mercury is added to a quantity of pure Olive Oil, and shaken with it. The per-nitrate is prepared by dissolving without heat, six parts by weight of Mercury in seven parts and a half of Nitric Acid, at about 38° of Reaumur's areometer; and 1.35 Spec. Grav. The saline solution remains fluid, the excess of Acid preventing its crystallization.

When 8 parts of this solution are mixed with 92 of pure Olive Oil, and shaken from time to time; after some hours, the whole congeals into a yellowish mass, and the next day it becomes solid like butter.

Observation. This singular property of the per-nitrate, renders it an excellent test of the adulteration of olive oil, by rape, poppy and other seed oils; as the impure mixture will not become concrete, but will congeal according to the quantity of olive oil in it. Another circumstance adds to the excellence of this test; namely, an *orange hue* which it imparts to the seed oils, also a resinous precipitate which is thrown down from them by it. On the contrary, the Provence olive oil is rendered only very slightly yellow like fresh butter, whilst the Calabrian is perfectly white like tallow.

CCCCLIX.

TESTS TO DISTINGUISH GLASS OF ANTIMONY FROM *Glass of Lead.*

Glass of Lead is often imposed on the ignorant for Glass of Antimony. To detect this fraud, it is necessary to observe the following mode of distinction.

Glass of Antimony has a rich brown or reddish colour, with the usual transparency of coloured glass. The glass of Lead is of a deeper and duller colour, against the light is much less transparent, and even, in some instances, it is quite opaque. The specific gravity of the true, never exceeds 4,95; that of the spurious is 6,95, or in round numbers, their comparative weights are as five to seven. Let twenty grains be rubbed fine in a glass mortar, adding half an ounce of Muriatic Acid; the true dissolves with an hepatic smell, the solution is turbid, but has no sediment. The spurious turns the Acid yellow, giving out an Oxymuriatic odour, and leaves much sediment.

Let a little of each solution be dropped separately into water, the true deposits Oxide of Antimony in a copious white coagulum, or, if the water has been previously tinged with Sulphuret of Ammonia, in a fine orange precipitate. The spurious gives no precipitate in water, but in the other liquid, one of dark brown or olive colour. A solution of the spurious in vinegar, has a sweet taste, together with the other properties of Acetate of Lead. A very small mixture of it may be detected, by its debasing, more or less, the bright orange colour of the precipitate, thrown down by Sulphuret of Ammonia from the solution in any Acid. The samples of the spurious, hitherto detected, are of a much thicker and clumsier cast than the genuine, but the appearance is not to be trusted, and no specimen should be allowed to pass without a trial, either of its specific gravity or chemical properties.

CCCCLX.

TEST FOR THE PURITY OF ALCOHOL.

It is a common practice for apothecaries, in order to ascertain if Spirit of Wine be sufficiently strong, to pour some into a cup upon Gunpowder, and then to set fire to it. If the Spirit be sufficiently strong, after burning down to the Gunpowder, it will inflame; but if too much water had been mixed with it, that would not take place, as, after the Spirit was consumed, there would still be water enough to keep the Gunpowder wet.

CCCCLXI.

TO DETECT SULPHUR IN HARROWGATE WATER.

It is well known, that when Silver combines with Sulphur, or is attacked by Sulphuretted Hydrogen, Gas, the compound (Sulphuret of Silver) is of a black colour. It is also well known that Harrowgate and other mineral waters of a similar nature are highly impregnated with Sulphuretted Hydrogen. Now although the smell of these waters is certainly sufficient to recognise the degree of impregnation, still the best test is Silver. Accordingly, throw a shilling into a tumbler of Harrowgate water: in a few seconds, it will be rendered quite black; that is, covered by a coat of black powder.

Observation. The sulphur of the mineral water leaves the hydrogen, to combine with the silver;-nearly the same effect will take place when a silver spoon is used, in eating an egg.

CCCCLXII.

To detect the Adulterations of Tea.

The Chinese sometimes mix the leaves of other shrubs with Tea, but this is easily discovered, (if not at first sight,) by making an infusion of it, into which put a grain and a half of blue Vitriol, or Copperas; if it be good genuine *green Tea*, and set in a good light, it will appear of a fine light blue; if it be genuine *bohea*, it will turn of a blue, next to black; but if they be adulterated, green, yellow, and black, colours will be seen in them.

After this fraud was detected, the Chinese *dyed* the leaves of damaged and ordinary *green tea*, with Japan earth, (Terra Japonica) which gives the leaf, the infusion, and the tincture, the colour, of *bohea*. This is to be discovered many ways: for, 1st, a less quantity of this dyed Tea, gives a deeper colour to the same proportion of water, than if it was good. 2dly, the colour it gives the water, will also be of a reddish brown, whereas it should be dark. 3dly, when the leaves have been washed by standing a little, they will look greener than good *bohea*. 4thly, this dyed Tea is generally much larger; therefore it is a good way also to buy the least leaf *bohea*. 5thly, the infusion, which should be smooth and balsamic to the palate, tastes rough and more harsh. 6thly, if milk is poured into it, it will rise reddish instead of a dark or blackish brown. 7thly, a little Sulphate of Iron put into this liquor, will turn it light blue, which otherwise ought to be of a deep blue, inclining to black. And 8thly, water of Ammonia makes the good Tea of a deep brownish yellow after it has stood a while, like new-drawn tincture of saffron; but it has not that effect in bad Tea.

Green Tea is also counterfeited, by dying bad *bohea* with green Vitriol. But this is also easily discovered: For, 1st, if a bit of Gall is put into the infusion, it will turn it of a deep black colour; which it would not do, were there no Sulphate of Iron in it, for galls do not tincture Tea naturally. 2dly, if the liquor is of a pale green, and inclines to a bluish dye, it is bad. 3dly, Spirits of hartshorn will make it of a purple colour, and cause a slight precipitation, instead of a deep greenish yellow, when it has stood for about six minutes.

GENERAL OBSERVATIONS *on some small articles of apparatus, for examining the most striking physical characters of* MINERALS.—*A magnet* ascertains the presence of iron in ores of that metal, as well as in those of titanium; more particularly if they be reduced to powder, and exposed to a red heat for a few seconds. Numerous ores, on which the magnet had originally no effect, become highly affected by it after being roasted.—*A magnetic needle*, will detect those minerals which already possess magnetic polarity.—*An electrometer* discovers whether minerals are susceptible of electricity by friction or heat; it is a brass wire, terminating with two balls, and is supported, at its centre, on a fine metallic point. A heated tourmaline, or topaz, being presented to the electrometer, the ball nearest to it will be attracted, shewing that the mineral has become electric. To determine whether the electricity be positive or negative; insulate the electrometer, by placing it on a reversed tumbler, or wine glass, then take a small glass tube, and rub it briskly upon a woollen cloth (by which it becomes positively electrified); now bring the tube within a short distance of one of the balls. After a few seconds, the electrometer will be electrified negatively, and on presenting the mineral, the ball will either approach, or recede, according to the kind of electricity which the mineral possesses.

The *steel mortar* is so constructed, as to reduce minerals to powder, without a particle escaping.—A *knife* is indispensible; it may contain a file, forceps, and bar magnet. It is recommended to try every specimen with the point, in order to obtain a knowledge of comparative hardness, colour, and texture.—*A platinum forceps* should be used to hold watch-glasses over the lamp, when the acids are employed.—*Glass tubes* are extremely necessary to hold solutions.—*Watch-glasses* are intended to contain the mineral and acids.—a *spirit lamp* is to be used in these experiments, as it does not emit smoke.—Rods of *zinc*, *iron*, *copper*, and *tin*, to produce metallic precipitates from solutions of the ores will be found very satisfactory in certain cases. When these rods are used, the solution should contain a slight excess of acid.

Platinum foil, is necessary for folding the earthy minerals, so as to prevent the escape of such as are likely to decrepitate, when exposed to strong heat.—*As a flux for the blow-pipe*, *borax*, for general purposes, answers sufficiently well; where a strong reducing flux is required, a few grains of *cream of tartar* may be added.

Any person possessing a mineral, with the nature of which he is unacquainted may proceed as follows:—If it be both earthy and metallic, he should separate one from the other and reduce a few grains to powder, which is to be placed in a watch-glass. To this add a few drops of nitric acid; if no action is perceived, it may be held over the flame of the lamp until ebullition takes place, when the substance will be more or less dissolved; then pour the liquid into a glass tube, previously containing a little water, and proceed by applying the tests or metallic rods.—Or expose the substance to the yellow flame of the blow-pipe, after which pulverize it, and apply the magnet; this will frequently determine the substance, iron being so generally disseminated. Or place it in a concave piece of charcoal, with an equal quantity of borax, and expose it to the blue flame, when it will melt into a bead [illegible] to the borax. Care must be taken not to apply too much [illegible] of the metals volatilise, or become oxidated.

CHAPTER X.

EXPERIMENTS ON THE PREPARATION OF GASES.

WHEN any body combines with Caloric to such a degree that it assumes the form of Air, and is able to retain a *permanently* elastic form, it is called a *Gas*. When, however, any aëriform substance, by an abstraction of its heat, is reduced or condensed so as to lose its elasticity, and thereby resume its liquid form, it is termed *Vapour*. A very familiar example of the former is the Air we breathe; and of the latter, we may adduce the aëriform state of steam from boiling Water. The latter is liable to condensation; whereas the former cannot be made to change its state by any means at present known.

The Gases form a very numerous class of chemical bodies, and possess properties the most wonderful, and opposite to each other. They possess weight like other bodies; their specific gravities being ascertained by comparison with that of Air, as those of liquids and solids are by the gravity of Water. Gases are generally colourless, but not always so, as in the case of Chlorine. Many of the compound Gases exhale peculiar odours. But the properties which best serve to distinguish them from each other are the relative powers which they possess in supporting combustion and animal life.

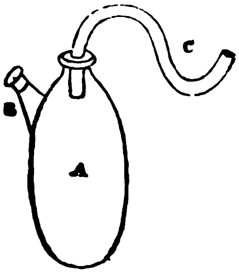
CCCCLXIII.

To obtain Oxygen Gas.

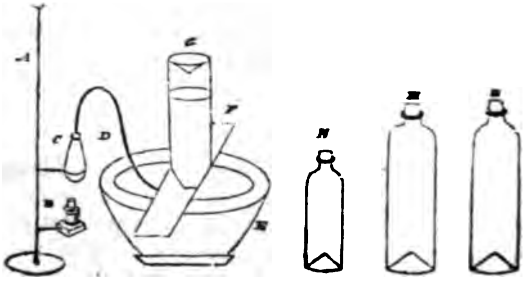
Put an ounce of pulverised Black Oxide of Manganese into a small glass retort, and pour over it the same quantity of Sulphuric Acid. Shake it in order that the substances may combine; and place the belly of the retort on a ring affixed to a stand over the flame of a lamp;

inclining the beak a little downwards, under one of the perforations in the shelf belonging to the pneumatic trough (Plate 2). The Gas will soon begin to come over, and should be received through the shelf in large phials or bell glasses, that have been previously filled with Water, and placed with their mouths over the holes. The Gas being lighter than Water will ascend, and, having dislodged that liquid, will occupy its place. When each phial is full, it should be tightly corked before it is removed from the shelf; or if a bell-glass be used, a common tea-saucer or soup-plate may be introduced under the surface of the Water, and the jar or glass may be carefully placed on it from the shelf. A sufficient quantity of Water must be left in the receiving dish, around the rim of the jar, to prevent the Gas from escaping, or mixing with Atmospheric Air. The dish and jar may now be removed, being fit for use; and another jar may be placed on the shelf to receive more.

A more simple and economical plan for obtaining small quantities of this Gas is, by using a bottle of the annexed shape for its distillation, and a common hand-bason as the trough. A is the body of the bottle, or mattrass; B, a tubulure or stopper for the admission of the Acid; and C, a sigmoid, or bent, glass tube, for the egress of the Gas as it is formed.



By way of fully illustrating this economical plan, a figure is here annexed of the whole of this simple



apparatus.—A, is the stand; B, the lamp; C, the mattrass; D, the bent tube, ground at one end to fit the mouth of the mattrass; E, the bason; F, the shelf; G, a phial in the act of filling; and H H H, phials filled with the Oxygen Gas.

Another mode of obtaining this Gas is as follows:—Put into a glass or other retort, half a pound of Red Oxide of Lead, and pour over it four ounces of Sulphuric Acid. Place the retort (if glass) in a sand-bath; or (if earthen) into a common fire or furnace, and receive the Gas in jars over Water in the Pneumatic trough.

Observations. In both these methods, it is obvious that the oxygen gas is set free by the union of the previously oxidised metals with the sulphuric acid.

When a bell-glass is to be filled with any kind of gas procured by means of a retort, &c. the gas should first be allowed to escape from the beak or mouth before it is put under the shelf of the pneumatic trough: by these means all the atmospheric air already existing in the retort and its beak, will be expelled. If this is not done, serious consequences may occur to the apparatus and the experimentalist, by the explosion of some gases in atmospheric air: at all events, the gases to be obtained cannot be pure for experiments, if they are allowed to be adulterated in this or any other way by combination with atmospheric air. Also, when bladders are to be filled, they should be twisted so as to expel all the air previously contained in them; and gradually untwisted as they are filled by the ascending gas. It is only by attending strictly to minutiæ such as are here noticed, that the results of experiments can be satisfactory.

CCCCLXIV

OXYGEN GAS PROCURED BY DRY DISTILLATION FROM THE BLACK OXIDE OF MANGANESE.

When much of this Gas is wanted, it may, with the greatest economy, be obtained as follows:—Pulverise eight ounces of the Black Oxide of Manganese in an iron mortar, and put the powder into an iron or earthen retort (see Plates 4 and 12): place the retort in a furnace; attach a proper tube well luted; and receive the Gas in collapsed bladders, or in a Gasometer through Water; or fill jars with it. In this way three or four gallons of Gas may be obtained.

CCCCLXV.

IMPREGNATION OF WATER WITH OXYGEN.

The very ingenious but laborious plan of effecting this curious purpose is related by M. Thenard in the eleventh volume of the *Annales de Chimie et de Physique:* from thence the detail of the necessary experiments was translated into the English journals as follows:

"The preparation of Oxygenated Water requires certain precautions, without which success will only be partial. That none may be omitted, I shall describe the process in the most minute manner.

"1. Nitrate of Barytes should first be obtained perfectly pure, and, above all, free from Iron and Manganese. The most certain means of procuring it is, to dissolve the Nitrate in Water, to add to the solution a small excess of Barytes Water, to filter and crystallize.

"2. The pure Nitrqte is to be decomposed by heat. This ought not to be done in a common earthen-ware vessel because it contains too much of the Oxides of Iron and Manganese, but in a perfectly white porcelain retort. Four or five pounds of Nitrate of Barytes may be decomposed at once, and the process will require about three hours. The Barytes thus obtained, will contain a considerable quantity of Silex and Alumine, but it will have only very minute traces of Manganese and Iron, a circumstance of essential importance.

"3. The Barytes, divided by a knife into pieces as large as the end of the thumb, should then be placed in a luted tube of glass. This tube should be long, and large enough to contain from 2 lbs. to 3 lbs. It is to be surrounded with Fire, and heated to dull redness, and then a current of dry Oxygen gas is to be passed through it. However rapid the current, the Gas is completely absorbed; so that when it passes by the small tube which ought to terminate the larger one, it may be concluded that the Deut-Oxide of Barium is formed. It is, however, well to continue the current for seven or eight minutes more. Then the tube being nearly cold, the Deut-Oxide, which is of a light gray colour, is taken out, and preserved in stoppered bottles.

"4. A certain quantity of Water, for example four pints, is then taken: to which is added as much pure and fuming Hydrochloric Acid as will dissolve 200 grains of Barytes. The acid solution is put into a glass with a foot, and ice placed round it, which must be renewed as it melts. Then 180 grains of the Deut-Oxide are to be very slightly moistened, and rubbed by portions in a mortar of agate, or glass. As these portions are reduced into a fine paste, they are to be removed by a box-wood knife, and placed in the fluid; they will soon dissolve without effervescence, especially if slightly agitated. When the solution is made, pure and concentrated Sulphuric Acid is added, drop by drop, the fluid being stirred at the time with a glass rod, until there is a slight excess of it, which is easily known by the property possessed by the Sulphate of Barytes formed at the moment, of readily depositing in flocculi; then, as at first, a fresh quantity of Deut-Oxide is dissolved in the fluid, which is again precipitated by Sulphuric Acid. The Deut-Oxide is always easy to distinguish from the Sulphate. It is is important to add enough Sulphuric Acid to precipitate all the Barytes, but not too much. If enough is not added, the fluid filters with difficulty, and slowly; if too much is added, the filtration also goes on badly. On arriving at the exact point mentioned, the filtration takes place with the utmost facility. When the filtration is completed, a small quantity of common Water is to be passed through the filter, and added to the first fluid; in this way the latter does not lose in volume: then, that nothing may be lost, it is necessary to spread the filter on a glass plate, to separate the substance from it, diffuse it through a small quantity of fresh Water, and filter it. The Water thus obtained is but slightly charged, but it is useful to wash the future filters.

"This operation being finished, another is made exactly similar to it, *i. e.* Deut-Oxide of Barium is to be dissolved in the fluid; the Barytes is to be precipitated by Sulphuric Acid, and so on; and the fluid is not to be filtered until after two solutions, and two precipitations. It is on this new filter that the Water obtained by washing the precipitate in the preceding operation is to be poured; after which fresh weak water is procured by washing the matter on the last filter.

"The second operation is followed by a third, that by a fourth, and thus, until the fluid is sufficiently charged with Oxygen. By using the quantity of Hydro-chloric Acid mentioned, 30 ounces of Deut-Oxide of Barium may be operated on, and a fluid will be obtained charged with 25 or 30 times its volume of Oxygen. If it is required to be further oxygenized, more Hydro-chloric Acid must be added.

"I have many times succeeded by this means in charging the fluid with 125 times its volume of Oxygen, but I added Acid enough to dissolve 463 grains of the Deut-Oxide, being careful also to preserve the acidity such, that at the end of the operation I could dissolve about 309 grains of the Deut-Oxide, without the aid of Sulphuric Acid; but I have ascertained that when the fluid contains nearly 50 volumes of Oxygen, it allows so much Gas to escape from one day to the next, that there is no advantage in continuing to oxygenate it by the Deut-Oxide.

"5. When the fluid is oxygenated up to the required point, it is to be saturated with Deut-Oxide, retaining it at the same time in ice. Abundant flocculi of Silex and Alumine soon separate from it, which are generally coloured yellowish-brown, by a little of the Oxides of Iron and Manganese. The whole should then be thrown quickly on a cloth, inclosed in it, and strongly compressed. This operation cannot be done well except by two persons, and should be performed rapidly; for though there is but a very minute quantity of Oxide of Manganese, it is sufficient to produce a considerable disengagement of Oxygen.

"6. As the fluid which has passed the cloth may still retain a small quantity of Silex, Iron, and Manganese, and as it is necessary to separate all these substances, it is again to be surrounded by ice, and Barytes Water added to it, drop by drop, the whole being stirred. If, when the Barytes is in such excess as to be slightly sensible to coloured paper, there is no precipitate, it proves that all the Oxide of Iron and Manganese are separated; if they have not been completely separated in the preceding operation, they will by this.

"Immediately on the separation of them, the fluid must be placed in two or three filters; for the Oxide of Manganese disengages so much Gas, that it cannot be removed too quickly. Sometimes double filters are required, because the Gas separating the paper, tears those that are single. Sometimes also, to avoid losses, the small quantities which remain in the filters first used, must be placed on fresh filters. Afterwards all the filters should be compressed in a cloth, to separate the water from them. Those which contain a comparatively considerable portion of Manganese, become so hot as to burn the hand.

" 7. The fluid which now contains only Hydro-chloric Acid, Water, and Oxygen, is placed in the glass it was first prepared in, and its temperature lowered by ice, as before. Then, stirring it continually, Sulphate of Silver, prepared by dissolving Oxide of Silver in Sulphuric Acid, is to be added, by small quantities at a time; and it is essential that the Sulphate contains no free Oxide. The Sulphate is decomposed by the Hydro-chloric Acid, and there results Water, Chloride of Silver which precipitates, and Sulphuric Acid in place of the Hydro-chloric. When the quantity of Sulphate of Silver added is sufficient to decompose, perfectly, all the Hydro-chloric Acid, the fluid suddenly becomes clear; until that is the case, it remains turbid. As it is required that no Hydro-chloric Acid should remain, so also no excess of Sulphate of Silver should be present; and therefore the fluid must be tested successively by Nitrate of Silver and Muriatic Acid, very small quantities of the fluid being used for this purpose.

" When the proportions are well adjusted, the fluid is to be passed through a filter, and the filter, after being allowed to drain, is to be compressed in a cloth. The fluid obtained by the compression, must be again passed through a filter, in consequence of a slight degree of turbidness.

" 8. The object of the preceding operations has been to obtain a fluid composed of Water, Oxygen, and Sulphuric Acid. But this acid must be separated; for this purpose the fluid is put into a glass mortar, surrounded by ice, and slaked Barytes, very pure and finely powdered, is to be added by small portions at a time; it is to be rubbed again in the glass mortar, and when it is all united to the acid, a fresh portion is to be added. When the fluid scarcely reddens Litmus Paper, it is to be filtered, and the filter compressed in a cloth; then, after having united

[illegible] immediately after, with all
[illegible] The excess of Barytes
[illegible] few drops of weak Sul-
[illegible] to leave a slight excess of
[illegible] the base, because the last
[illegible] whilst the first renders the
[illegible]

[illegible] may be considered as pure
[illegible] with common Water, is to
[illegible] having a foot, and this glass
[illegible] two-thirds full of concentrated
[illegible] apparatus is to be placed in the
[illegible] and a vacuum made. Pure
[illegible] tension when in vapour, than
[illegible] evaporates more rapidly, so that at
[illegible] fluid will contain perhaps two
[illegible] volume of Oxygen. The fol-
[illegible] be attended to:
[illegible] agitated from time to time.
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[illegible] disengages a little Gas, which is indi-
[illegible] of the Mercury in the gauge.
[illegible] occasioned, no doubt, by extra-
[illegible] which remain in the fluid; it may be
[illegible] of two or three drops of ex-
[illegible] Acid.
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[illegible] should be separated. The fluid may be
[illegible] with a very fine termination, and but
[illegible] will be lost.
[illegible] becomes very concentrated the evapo-
[illegible] quietly, but when the Oxygenated
[illegible] any more Water, bubbles fre-

then observed, is in part occasioned by the disengagement of Gas from the Sulphuric Acid, belonging to a portion of the Oxygenated Water which has been evaporated.

"The fluid may be known to be in the most concentrated state possible, when it gives four hundred and seventy-five times its volume of Oxygen at the pressure of 30 inches, and temperature of 57.2 Fahr. This proof is readily made by taking a small tube, on which a line is marked, and filling it with the fluid up to the line, and then diluting this quantity, which, in my experiments was always $\frac{5}{100}$ of a centilitre (0,030514 of c : i :) with twelve times its volume of Water, and decomposing a certain quantity of this last fluid by Oxide of Manganese. This last experiment consists in filling a tube 15 or 16 inches long, and 7 or 8 lines wide, with Mercury, to within an inch of the top; then introducing the portion of diluted fluid, of which the analysis is to be made, using for this purpose a small tube of known capacity, afterwards filling the tube with the Water used to wash the small measure, or partly with Mercury, and then, by closing the tube with a valve covered with tallow, inverting it, and passing in a little Oxide of Manganese diffused in Water. The Oxygen will be immediately disengaged, and nothing further is required than to close the tube with the hand, and shake in different directions, that the contact of the Oxide of Manganese and the Water may be ensured, and to measure the Gas."

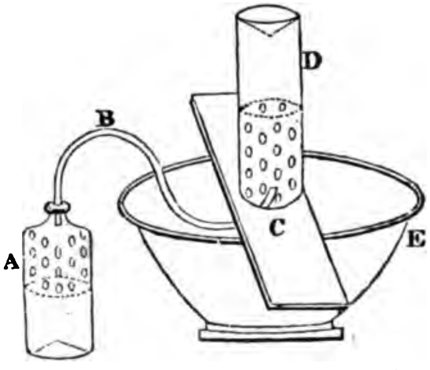
Observations. Oxygenated water is colourless and is devoid of smell in ordinary circumstances, but has a particular odour in vacuo. It acts on the skin like a sinapism. Its specific gravity is 1.453, and when poured into common water, it is seen to flow down through it like a syrup, although very soluble. It immediately acts on the epidermis of the skin, rendering it white, and producing smarting, which varies in duration according to the quantity of the fluid placed on the skin; if it is considerable, or if fresh portions are added, the skin itself is attacked and destroyed: applied to the tongue, it whitens it also, thickens the saliva, and, with regard to taste, produces an effect difficult to describe, but which resembles that of an emetic. Its action on the oxide of silver is very violent. Each drop suffered to fall into dry oxide of silver produces a real explosion, and so much heat is produced, that, in a dark place, the evolution of light is very sensible. Besides the oxide of silver, there are several others which act with violence on Oxygenated Water, as the peroxides of manganese and of cobalt, the oxides of lead, platinum, palladium, gold, iridium, &c. Many metals, when finely divided, also produce the same phenomena; and among others, silver, platinum, gold, osmium, iridium, rhodium, and palladium. In all these cases, the oxygen added to the water is disengaged; and sometimes that of the oxide; but at other times, a part of the oxygen combines with the metal itself, as with arsenic, molybdenum, tungsten, and selenium. These metals are acidified frequently, with the production of light.

CCCCLXVI.

Hydrogen Gas.

Into a tubulated retort put an ounce and a half of Iron Filings, and pour over them the same quantity of Sulphuric Acid, diluted with eight ounces of Water. Now place the beak of the retort directly under one of the perforations of the pneumatic shelf, which is to have a jar or bottle filled with Water inverted immediately over it. The Gas will be extricated in the retort, and from its levity will ascend in the jar, bubbling, and displacing the Water. In this way successive jars may be filled.

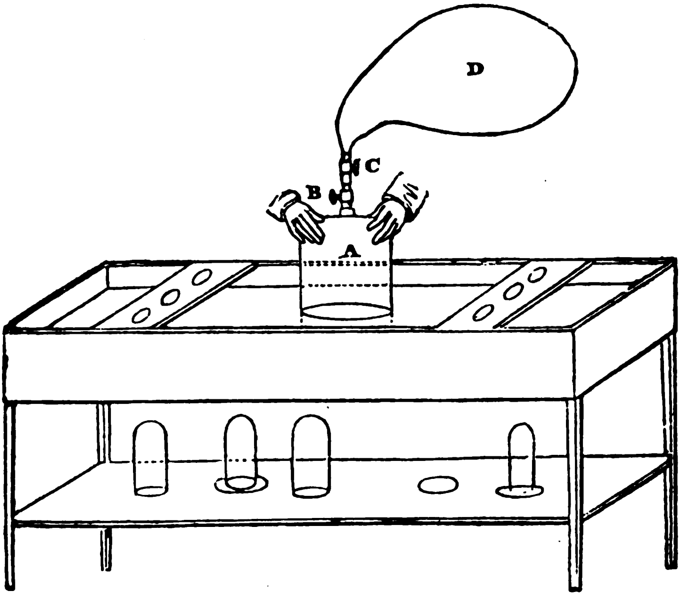
Where it is not convenient to use the pneumatic trough, Hydrogen Gas may be procured, with much economy, by using a wash-hand-bason and other simple apparatus, according to the following figure:



A, the phial containing the diluted acid and the filings; B, the bent tube; C, the shelf; D, the receiving vessel; and E, the bason answering the purpose of a pneumatic trough.

Observations. In this experiment, the water in combination with the acid oxidises the iron filings, and is thereby deprived of its oxygen; for in order that the metal may be dissolved by the acid, it must be first oxidised, and for that purpose it rapidly abstracts the oxygen from the water, by which means the water is decomposed, and the hydrogen is set free.

As it is necessary to fill bladders with hydrogen gas for the purpose of experiment (as in the combustion of hydrogen), the following cut is inserted to exhibit the mode of filling them. By taking the jar A from the shelf, and pressing it downwards



in the water, the gas issues from the cock B into the cock C, and enters the empty bladder D, which is consequently inflated. When the bladder is quite full, both cocks are to be turned, to prevent escape of the gas.

CCCCLXVII.

HYDROGEN GAS OBTAINED BY THE DECOMPOSITION OF WATER BY RED-HOT IRON.

Another method of procuring Hydrogen Gas is, by passing the steam or vapour of Water through a red-hot iron tube, as follows. Pass a gun-barrel (the breech of which has been cut off) through a furnace (as in Plate 11th), and apply the beak of a retort which is half filled with Water to one end of it. Place the retort upon a stand, and apply a lamp under it. Now affix to the other end of the tube or gun-barrel, a bent tube connected with a receiver. The Water passing in the state of steam over the internal surface of the red-hot barrel, will be decomposed; its Oxygen uniting with the Iron forming Oxide of Iron, whilst the Hydrogen is set free. The same results will take place, when an earthen tube, containing Iron Filings, is used. If the Filings, which have been thus oxidised, be afterwards weighed, they will be found to have increased one-third more than their original weight.

Observations. By this experiment it is obvious that hydrogen constitutes one part of water; and if the oxidised filings be submitted to great heat, they will give out the other constituent of water, viz. the oxygen, which they received by the decomposition above illustrated. Hence, by this *analysis,* water is proved to be a compound body: and to banish all doubt of the really wonderful fact that these two gases coalesce to form this salubrious and universally supplied fluid, *synthesis* has been had recourse to: that is, the two gases have been burnt together; or rather the hydrogen has entered into, and continued in a state of active combustion by a continued supply of oxygen, and the result has been the formation of *water.* This surprising but pleasing effect is detailed in experiment 194, and the apparatus is exhibited in Plate 10.

Red-hot charcoal likewise has the power of decomposing water; and there can be little doubt, that when water, in quantities so small as those emitted from a common engine-pipe, are thrown upon burning houses, the beams, &c. which are suffering a rapid conversion into charcoal, decompose it as fast as it is thrown upon them; thus setting immense volumes of hydrogen free, which of course take fire as soon as they are evolved, and add greatly to the combustion.

CCCCLXVIII.

To procure Nitrogen Gas.

Wash a piece of Beef well, and cut it into very small bits; put these into a tubulated retort and place them over a lamp. Now pour in some diluted Nitric Acid, and insert the beak under a receiver standing on the shelf of a pneumatic trough. Nitrogen Gas will come over, and fill the glass or glasses.

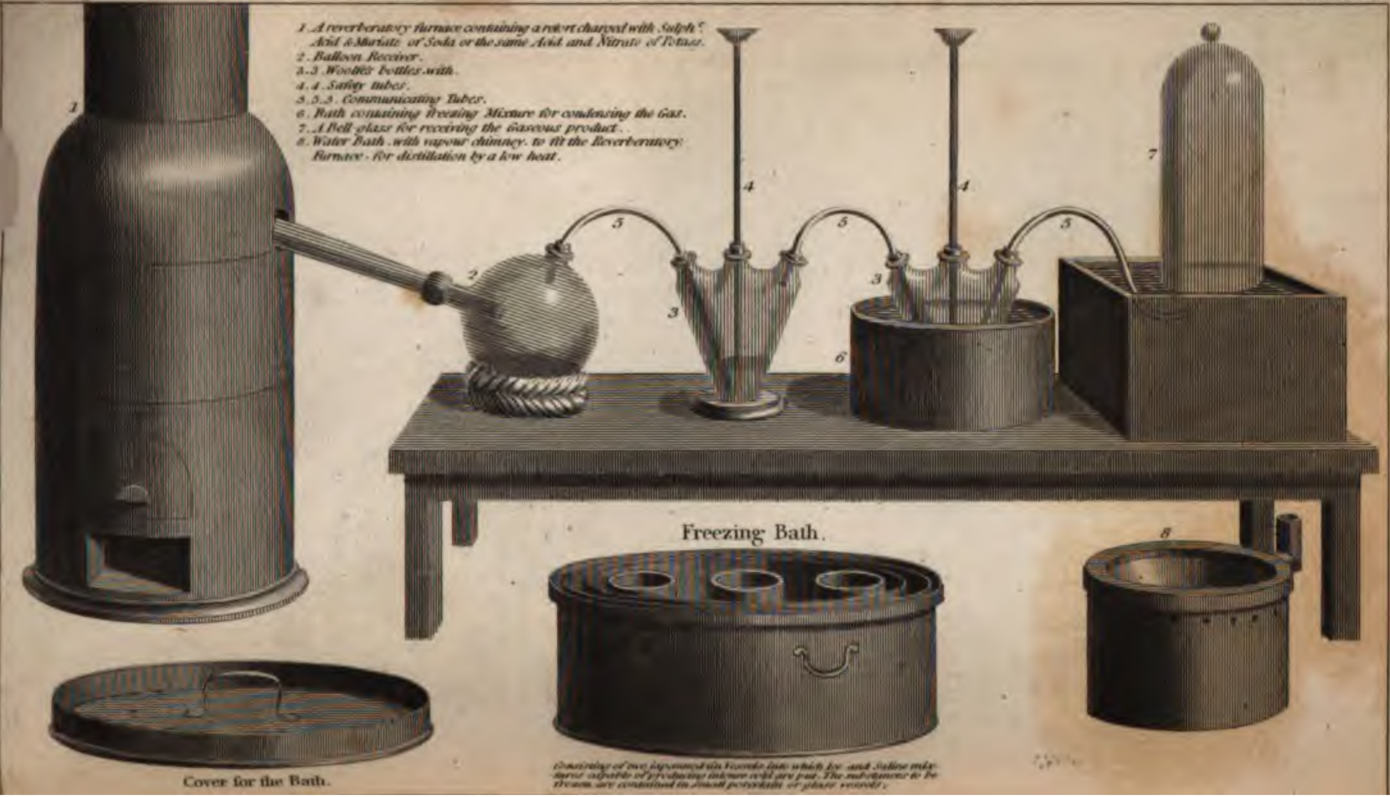
Observations. Nitrogen gas is somewhat lighter than atmospheric air, of which it forms about three-fourths. It exists abundantly in nature, is the peculiar and almost characteristic ingredient of animal matter, the basis of the nitric acid, and one of the constituents of ammonia; it is capable of indefinite condensation and expansion, like atmospheric air.

CCCCLXIX.

Chlorine Gas.

Put an ounce of pulverized Oxide of Manganese into a retort, and pour over it 2 ounces of Muriatic Acid. Now

Apparatus for the Preparation of Nitric, and Muriatic Acid.



1. A reverberatory furnace containing a retort charged with Sulph^c. Acid & Muriate of Soda or the same Acid and Nitrate of Potass.
2. Balloon Receiver.
3.3. Woulfe's bottles with.
4.4. Safety tubes.
5.5.5. Communicating Tubes.
6. Bath containing freezing Mixture for condensing the Gas.
7. A Bell-glass for receiving the Gaseous product.
8. Water Bath, with vapour chimney, to fit the Reverberatory Furnace, for distillation by a low heat.

Freezing Bath.

Consisting of two Japanned tin Vessels into which Ice and Saline mixtures capable of producing intense cold are put. The substances to be frozen are contained in small porcelain or glass vessels.

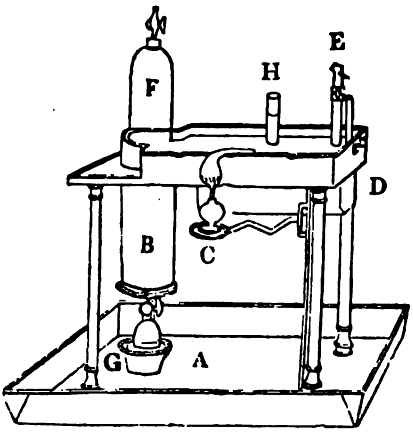
Cover for the Bath.

place the retort on a ring, belonging to a stand, over a lamp, as in Plates 2 and 13, and apply the beak to one of the holes in the pneumatic shelf, taking care that a jar of Water is over the hole. The Gas will soon come over and displace the Water in the jar; the jar, when empty of Water, and full of Gas, must be received on a plate or saucer, and set aside for use; and other jars may be filled in succession. If bottles are the recipients of this Gas, care must be taken to cork them well before they are taken from the trough.

Observations. Chlorine gas may also be obtained in the same manner (namely, by the use of a hand-bason and flask) as oxygen gas. This gas may also be obtained by substituting the red oxide of lead for the oxide of manganese.

In all these modes for the preparation of chlorine gas, it is evident that the muriatic acid acts so upon the oxide as to cause its own hydrogen to combine with the liberated oxygen, and form water; while the chlorine (which was the other component of the acid) assuming the elastic form by combination with the caloric disengaged by the mutual decomposition, is evolved through the water and received into the jars.

It is necessary to be observed here, that chlorine, and all other gases readily absorbable by water, should be received over *mercury*, in a trough made for the purpose of containing from a dozen to twenty pounds. These troughs, which are made of cast-iron, are so contrived as to render this small quantity of the fluid metal sufficient for experimental purposes (see Plate 2). The annexed cut exhibits the mercurial trough in its most improved condition. The apparatus itself may be had of Mr. Newman, Chemical instrument maker, Lisle-st. Leicester-square, London.—A is a varnished tin tray to prevent a waste of any mercury which may overflow; G a retort, with tube and stop-cock, communicating with the conductor B, and the bell-glass F, for the reception of the gas: C and H are also a retort and receiver for preparing the gas on a small scale; D is the trough containing the mercury; and E is a detonating tube for the explosion and condensation of the gases.



CCCCLXX.

TO IMPREGNATE WATER WITH CHLORINE.

For this purpose, nothing further is necessary on common occasions than to pour some distilled Water into a jar or large phial containing Chlorine, and to agitate them together.

The solution of Chlorine will be of a greenish yellow colour. When Chlorine and Water are left in contact, an absorption (but rather slowly) takes place.

Observations. All gases, with which it may be required to impregnate water, should be passed through a series of Woolfe's bottles or receivers (see Plate 4); as whatever quantity of gas refuses to combine with the water in one vessel, is at liberty to pass through a connecting tube into the next, and so on. To some of these receivers there are safety-tubes attached, in which there is a globule of mercury which can be raised by the gas, so that whilst the apparatus are preserved from bursting, there is none of the gas allowed to escape. Although this mode is expensive, it is still the most elegant one, and by far the most certain for obtaining accurate results

CCCCLXXI.

IODINE VAPOUR.

Put a small quantity of Iodine into a retort, and hold it over a lamp: when heated considerably (about 300°) a very beautiful vapour or Gas will come over, which may be received in jars on the pneumatic shelf, over Water.

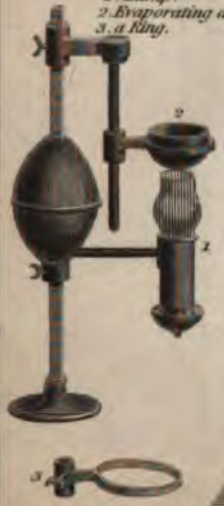
CCCCLXXII.

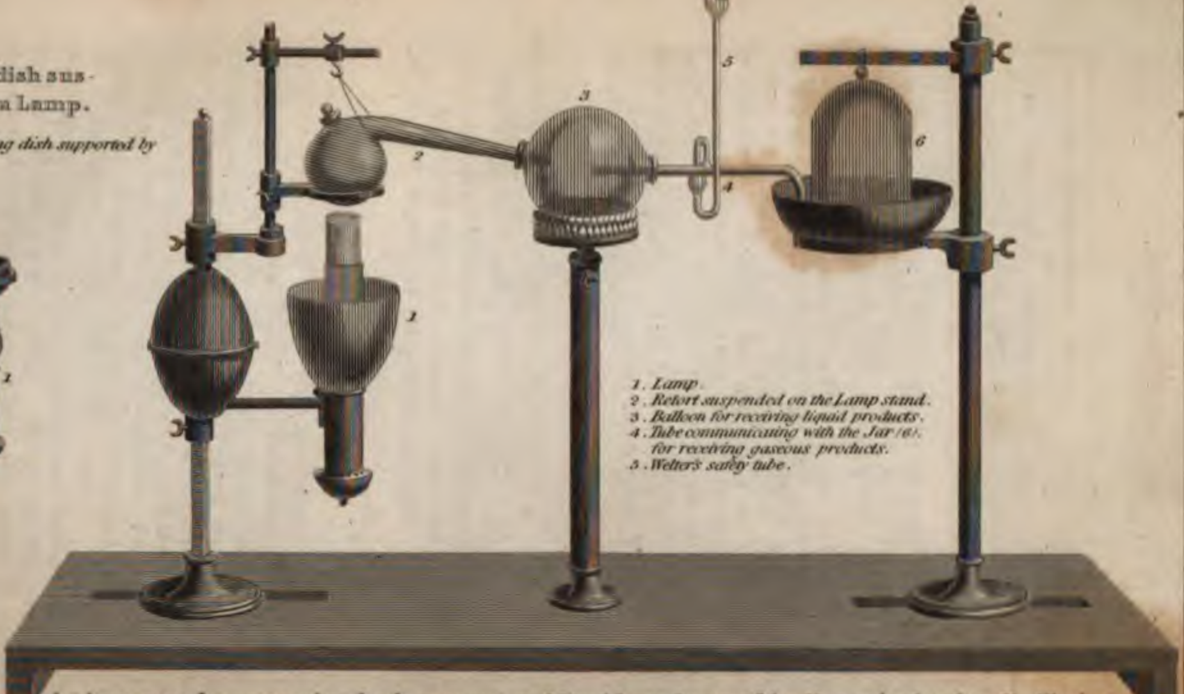
CARBONIC ACID GAS.

Into a glass tumbler put half an ounce of powdered chalk, and add to it a drachm of Sulphuric Acid. Very little agitation will take place owing to the want of power which the acid has to diffuse itself among the particles of chalk. But if the tumbler be one-third filled with Water, the acid will hastily combine with it, and thus becoming diluted, will present so large a surface to the chalk, as to attack it at all points, seizing the lime, and driving off the Carbonic Acid with great effervescence. By holding the nose over the tumbler, the peculiar odour of the Carbonic Acid may be perceived. When the effervescence is at an end, a white powder will subside at the bottom of the tumbler, which is Sulphate of Lime.

Evaporating-dish suspended over a Lamp.

1. Lamp.
2. Evaporating dish supported by
3. a Ring.





1. Lamp.
2. Retort suspended on the Lamp stand.
3. Balloon for receiving liquid products.
4. Tube communicating with the Jar (6). for receiving gaseous products.
5. Welter's safety tube.

An Apparatus for preserving both gaseous and liquid products of bodies, submitted to distillation.

Observation. If a piece of moistened litmus paper be held over the tumbler during the disengagement of the gas, it will be reddened by it. This proves the gas to be acid.

CCCCLXXIII.

PRODUCTION OF CARBONIC ACID GAS BY COMBUSTION.

Immerse a piece of ignited Charcoal in a jar of Oxygen Gas. A very beautiful and rapid combustion will immediately take place. The Charcoal will at last be consumed, and of course the combustion will cease. On inspection, the glass will be found filled with Carbonic Acid Gas. This Gas will be absorbed by quick lime, or by lime water (which it will render turbid) placed at the bottom of the jar; from this combination it may afterwards be expelled by diluted Sulphuric Acid. That Carbonic Acid has been formed, may also be proved by the extinction of a candle, or taper flame.

CCCCLXXIV.

TO PROCURE CARBONIC ACID GAS IN QUANTITY SUFFICIENT FOR THE PURPOSES OF EXPERIMENT.

Put four ounces of powdered Chalk into a tubulated glass retort, and pour over it four ounces of diluted Sulphuric Acid. The acid will seize upon the Lime, forming Sulphate of Lime, and will expel the Carbonic Acid, which may be received in glasses in a pneumatic trough, or in a bladder in a collapsed state attached to the beak of the retort. If a bladder be used, smaller quantities of the Chalk and Acid may be employed.

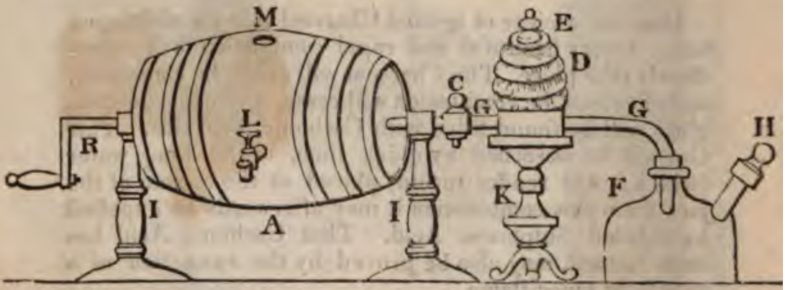
Observations. Various kinds of apparatus have been used for impregnating water with carbonic acid gas. In Plate 3, there is one invented by Dr. Nooth,' and in plate 9 there is a modification of it, on a larger scale. Plate 15 represents an apparatus used in France, which is merely a series of Woolfe's bottles connected with each other by means of glass tubes. There are also safety tubes affixed, to prevent the bursting of the apparatus.

Water impregnated with carbonic acid, should not be made in copper, or indeed in any metallic vessels, as it rapidly dissolves that metal. The acid should also be passed through some alkaline solution, which will separate from it any sulphurous vapour which might be apt to come over with it.

CCCCLXXV.

CONVENIENT AND SIMPLE MODE OF IMPREGNATING WATER WITH CARBONIC ACID GAS.

According to the following figure, suspend an air tight barrel A, having a cock L, and a handle R, between two pillars I I; attach to one side a tube G G having a cock C, passing through a varnished air tight bellows D, into a bottle F; the bottle has a cock H, and on the top of the bellows the weight E is to be occasionally placed; the tube is to open into the bellows, and again further on into the barrel. When the apparatus is to be used, pour distilled or spring Water into the bung-hole M, until the barrel is half filled; then put in an air tight bung, and place over it a jointed hoop, which is to be locked by a linch pin to prevent the bung from being forced out by the elastic force of the Gas. Now pour into the tubulure of the bottle some diluted Sulphuric Acid over a quantity of powdered Carbonate of Lime (chalk). The Carbonic Acid generated in the bottle will ascend through the tube into the bellows, which will rise from distension. When the bellows is full, the cock C is to be turned, and the weight E is to be placed upon the top of the bellows, which will of course press the Gas downwards through the tube into the barrel. As this Gas is readily absorbable by Water, that in the barrel will soon be impregnated by it; but more especially when the barrel is quickly turned. Stone bottles quickly filled with this Carbonated Water will preserve it good and pure for many months, if the corks are bound down by copper wire.



Observations. There are various establishments in London, and elsewhere, where carbonated water is sold as a beverage. Other liquors, such as spirituous, saccharine, and aromatic, are also impregnated by this gas. In the large way, these are saturated under a considerable pressure, which is reduced, in part, on the liquors being bottled. The decantation is effected by stopping the mouth of the bottle or jar with a perforated cork, leather, &c. through which the decanting tube passes, so that on opening the cock, the aerated liquor rushes into the bottle, till resisted by the condensation of the atmospheric air it originally contained; and a portion of carbonic acid gas is extricated during the effort. When full, the bottle may be withdrawn and stopped with ease, by letting off slowly a small portion of the fixed air contained before its removal. In some cases the decanting-cock is constructed so as to allow the stopper to pass into the bottle, &c. previously to its removal from the flat air-tight fitting; by which means the entire pressure may be retained.

CCCCLXXVI.

EXTEMPORANEOUS PREPARATION OF A SALINE CARBONATED DRAUGHT.

Pulverise 1 ounce of Citric Acid, and divide it into 24 parts; that is, 24 scruples, which are to be put into separate small papers (blue paper will be best, as the acid will be thus known from the Alkaline Salt, which we shall presently notice). Pulverise also 1 ounce of the Sub-Carbonate of Soda, and divide it into 24 like packages, in *white* paper. When the draught is to be prepared, put the Carbonate into a tumbler, half filled with spring or filtered Water: when this is completely dissolved, add the acid, which will immediately cause an effervescing discharge of Carbonic Acid. During this effervescence swallow the draught; it will be found very refreshing in warm weather.

Observations. It must be kept in mind, that the above-mentioned draught is not purely carbonated water, for it holds a quantity of citrate of soda in solution. This, however, is far from being unpleasant.

A similar preparation may be made by using tartaric acid instead of the citric. Here there will be a discharge of carbonic acid gas, and a solution of tartrate of soda.

Many naturally acidulous springs owe their properties chiefly to carbonic acid; they sparkle when drawn from the spring, or when poured into a glass, having an acidulous taste, but become vapid when exposed to the air. Besides free carbonic acid, on the presence of which their qualities depend, these waters contain, generally, carbonates of soda, lime, magnesia, and iron; and sometimes muriate of soda. Some are *warm*, others *cold*. The most celebrated of these springs are Pyrmont, Seltzer, Spa, and Carlsbad.

CCCCLXXVII.

NITROUS GAS.

This Gas may be procured by putting half an ounce of Mercury or Copper filings into a tubulated retort, and pouring over them an ounce of diluted Nitrous Acid. In combining with the Metal, a considerable quantity of Gas will be evolved, which may be received in a jar over Water or Mercury (see Plate 14).

CCCCLXXVIII.

PREPARATION OF NITROUS GAS BY THE DECOMPOSITION OF AMMONIA AND OXIDE OF MANGANESE.

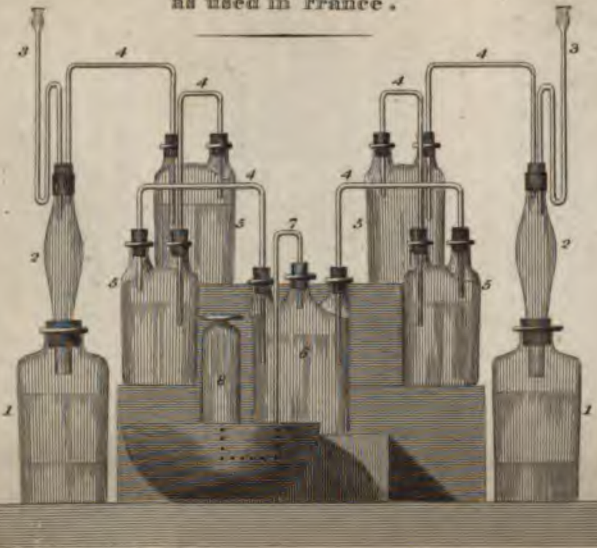
Place an earthen tube nearly filled with the Oxide of Manganese, horizontally in a furnace, similar to the one used in the decomposition of Water by means of a gun-barrel (Plate 11). Adjust a retort containing a solution of pure Ammonia to one end; letting it rest over a lamp: to the other end lute a bent glass tube, one end of which is to be placed under the shelf of a pneumatic trough. When the Oxide of Manganese has received a heat so strong as to decompose it, kindle the lamp, that the Ammonia may rise in vapour, and pass through the earthen tube. When some of the Gases have escaped through the Water, paste a piece of Litmus paper on the inside of a jar, and having filled it with Water, place it on the shelf. As the Nitrous Gas fills the jar, the paper will acquire a red colour. As another test of its being Nitrous Gas, pour some Hombergs Pyrophorus into it, which will inflame; or, as a further proof, lift a jar filled with it, and expose it to the air; here, red fumes will indicate that Nitrous Gas was contained in the jar. In the formation of this Gas, the Nitrogen of the Ammonia combines with some of the Oxygen of the Oxide,.whilst the rest of the Oxygen with the Hydrogen forms Water.

CCCCLXXIX.

MURIATIC, OR HYDRO-CHLORIC GAS.

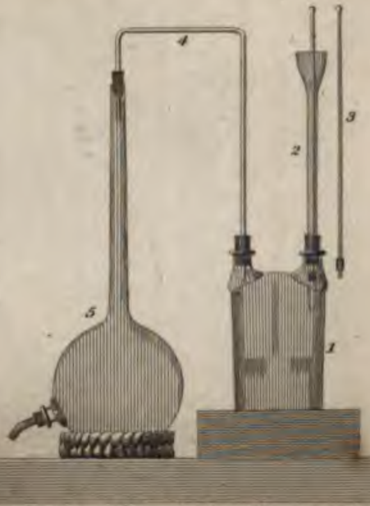
Put an ounce of Muriate of Soda into a tubulated retort above a lamp, and pour an ounce of diluted Sulphuric Acid over it: the Soda leaves the Muriatic Acid (which will fly off in a gaseous form) and attaches itself to the

Apparatus for the Impregnation of Water by Carbonic Acid Gas, as used in France.



1.1. Bottles containing the Chalk and Acid.
2.2. Wide tubes fixed through Corks in these bottles.
3.3. Safety tubes attached to these, with others

Modification of this Apparatus.



1. Bottle for Chalk and Acid which are supplied by
2. the tube and funnel.
3. A lengthened stopper to fit the extremity of the tube.

Sulphuric Acid, forming Sulphate of Soda. The Gas may be received in a jar, over Mercury

CCCCLXXX.

EUCHLORINE, OR PROTOXIDE OF CHLORINE.

Pour one ounce of Muriatic Acid, diluted with an ounce of distilled Water, over one ounce of Chlorate of Potass in a retort placed over a lamp, the heat of which is rather gentle. Receive the Gas which ascends, over Mercury. This Gas has a yellowish green appearance.

CCCCLXXXI.

SULPHUROUS ACID GAS.

Pour two ounces of Sulphuric Acid over an ounce of Copper Filings in a glass retort, and place the retort on a ring over a lamp: when ebullition (that is, the action of the acid on the metal) commences, plunge the beak under a bell-glass standing in a mercurial pneumatic trough. A Gas, which is the Sulphurous acid, will ascend, and displacing the Mercury, will fill the glass.

CCCCLXXXII.

AMMONIACAL GAS.

This Gas is generally produced from animal matters, and by its readiness to combine with Carbonic Acid, we are enabled to possess it in a tangible, or concrete form as Carbonate of Ammonia. The following methods of preparing Ammoniacal Gas, synthetically, will be found amusing and satisfactory, insomuch as they thus prove the composition of this Gas, which by analysis had before been accounted a compound of Nitrogen and Hydrogen.

Put some granulated tin into a tea-cup, and pour over it a little strong Nitric Acid, so as to do little more than to moisten it. The metal will be acted on by the acid, and red fumes of Nitrous Gas will arise: when this action has ceased, pour into the cup a little of the solution of pure Potass. A very pungent vapour or gas will now arise, which from its odour may be known to be Ammonia.

Observations. Here we must be assured that the Ammonia is synthetically produced by the decomposition of the substances employed; for we are aware that Ammonia itself did not enter into the composition. Ammonia being composed of Nitrogen and hydrogen, we must account for its formation by the evolution of these gases in such proportion as to form it. In the first instance, however, the ammonia is not perceptible by its odour, because at the instant of its formation, it is attacked by some of the nitric acid, and thus nitrate of ammonia is combined with oxide, or nitrate of tin. The addition of solution of potass, however, by combining with the nitric acid, liberates the ammonia from its dormant state, and consequently its odour is exhaled.

CCCCLXXXIII.

Production of Ammonia by the Decomposition of Water by Iron Filings, in an Atmosphere of Nitrogen Gas.

Prepare a jar of Nitrogen Gas, by filling it in a Mercurial apparatus, and immerse in it quickly a small vessel of any kind containing some moistened Iron filings. Leave it in this state until the Iron be rusted or oxidated by decomposition of the Water. When this takes place, open the jar; an Ammoniacal smell will be perceived.

Observation. In this experiment, the iron combines with the oxygen of the water, setting the hydrogen free to combine with the nitrogen in the jar.

CCCCLXXXIV.

Preparation of a Solution of Ammonia in Water.

Pour half a pint of distilled Water over 9 ounces of fresh calcined lime, in a large stone jar; cork it close, and in the course of an hour add 12 ounces of Muriate of Ammonia in 3½ pints of boiling Water. Shake the whole together, and when it is cold pass it through a filter. Pour the solution into a glass retort, and distil by a sand heat until 18 or 20 ounces have come over into the receiver. Preserve this liquid in well-stoppered bottles.

Observations. Here the muriatic acid, by means of heat, leaves the ammonia to unite with the lime; the ammonia is consequently volatilised.

Gaseous ammonia may be procured by putting 1 ounce of pulverised muriate of ammonia with 2 ounces of pulverised unslacked lime into a retort above a lamp, and receiving it in the mercurial pneumatic apparatus, or in bladders.

CCCCLXXXV.

Nitrous Oxide Gas.

Put some Crystals of Nitrate of Ammonia into a retort, and expose them to a heat of about 400°. Allow some of the Gas which comes over first, to escape ; and then immerse the beak of the retort under a jar on the shelf of a Pneumatic trough. The jar will speedily be filled with Nitrous Oxide Gas : it should be well washed before use. This Gas is sweet to the taste, and possesses very peculiar properties.

CCCCLXXXVI.

ABSORPTION OF NITROUS OXIDE GAS BY WATER.

Fill a jar with Nitrous Oxide Gas, and having taken it from the shelf on a saucer, place it in a deep bason containing Water that has been boiled to expel the common Air. Cover the bason with a cloth, to prevent, as much as possible, the access of the atmosphere ; and let the whole remain in this state for some time. Very soon the Water will be risen in the jar,—a proof that the Gas has been absorbed. It is very remarkable, that if the jar be now carefully removed, and its contents poured into a retort ; and if the retort be put over a lamp, this Gas may be recovered in the usual way over Water. This is a proof, that though Gases may be intimately, they are not chemically, combined with Water. When Water absorbs much of this Gas, it is a test of its purity

CCCCLXXXVII.

ARTIFICIAL FORMATION OF ATMOSPHERIC AIR.

Mark two large glass jars in such a manner that when they are turned upside down, the upper compartments (in that position) shall be one-fifth of the whole capacity of each jar :—supposing that each jar contains 20 ounces of Water, pour out one-fifth, that is, 4 ounces, into a graduated glass ; then cork the jars and turn them upside down ; now, mark on the side of the jars how far the Water has descended. This mark may be made with Indian ink or any water colour. Fill again both jars with Water, and place them over a shelf. Into each let pure Oxygen Gas pass from a retort, until the Water falls to the mark ; now withdraw the retort and apply another from which Nitrogen Gas issues. Fill the remaining four-fifths of each jar with this latter Gas : when they are full, that is, when all the Water is expelled, cork them under Water, and withdraw them from the shelf.

Into one of the jars put an animal, such as a mouse, and into the other a lighted taper; cork them both. The animal will live, and the taper will burn as long as either of these would do by being immersed in corked jars of common atmospheric air, of the same capacity. These are proofs by synthesis that Atmospheric Air is composed of four-fifths of Nitrogen, and one-fifth of Oxygen Gas; for this experiment demonstrates that these proportions are equally capable of supporting life and combustion, and for the same length of time, as Atmospheric Air: and that consequently, in the grand laboratory of nature, these are the proportions used in the formation of that Air.—The generally received proportions of the constituents of common Air, are 22 of Oxygen, to 78 of Nitrogen Gas, which are almost as one-fifth to four-fifths.

Observations. Besides these gases, it has been ascertained that others are occasionally combined with it.

M. T. de Saussure has determined, by experiment, the relative proportion of carbonic acid in the atmosphere during summer and winter. His method was, to fill a large glass globe with the air to be examined, and to put into it a quantity of barytes water. The carbonic acid in the air was determined by the quantity of carbonate of barytes formed. In winter 10,000 measures of air in volume gave a mean of 4.79 parts of carbonic acid gas. In summer the same number of measures gave 7.13 parts.

CCCCLXXXVIII

ABSORPTION OF AIR AND OTHER GASES BY CHARCOAL.

If three or four pieces of very dry Charcoal are put under a small bell-glass which is placed over Mercury, it will, if left undisturbed, absorb all the Air above the Mercury: this will be very evident by the ascension of the Mercury in the glass. But if a few drops of Water are introduced into the glass through a bent tube, this Water being specifically lighter, will ascend to the top of the Mercury and be absorbed by the Charcoal; at the same time, the Air will be set at liberty. This will be seen by the sinking of the Mercury in the bell-glass, which of course could not take place if some fluid did not press it downwards. This fluid, by the aid of other experiments, may easily be proved to be common atmospheric Air.

Observations. If pieces of charcoal be placed under glasses containing other gases, this absorbent power will be equally perceptible. The gases are supposed to be condensed in its cells. Even water is said to have been formed in pieces of charcoal by the combination of oxygen and hydrogen gases.

CCCCLXXXIX.

SULPHURETTED HYDROGEN GAS.

Put 1 ounce of Sulphuret of Iron into a tubulated retort, and pour over it an ounce of diluted Sulphuric Acid. The Sulphuric Acid, in attacking the Iron, will receive the assistance of the Oxygen of the Water (by which it was diluted) in oxidising the Metal before it is converted into Sulphate of Iron. The Hydrogen of the Water will thus be free to combine with the Sulphur. The Sulphuretted Hydrogen may be received in the common way in a Pneumatic apparatus, or in a bladder attached to the beak of a retort.

Observations. The following is M. Gay Lussac's method of preparing sulphuretted hydrogen gas.

"The way I obtain this gas is, to mix two parts of iron filings with one of flowers of sulphur, then to put it into a mattras with as much water as will give it the consistence of soup, and beat the vessel, to promote the union of the sulphur and iron, which soon shows itself by a great disengagement of heat, and a black colour spreading through the whole mass. Then, sulphuric acid diluted with four times its volume of water, disengages the sulphuretted hydrogen with nearly as much rapidity as from an alkaline hydro-sulphuret. The mixture should never be prepared before the gas is to be obtained."

CCCCXC.

IMPREGNATION OF WATER BY SULPHURETTED HYDROGEN GAS

Put some Sulphuret of Iron into a tubulated retort, and connect it with a receiver and Woolfe's bottles containing distilled Water (see Plate 4): pour diluted Sulphuric Acid into the retort. The acid will form with the Iron, Sulphate of Iron, and the Sulphuretted Hydrogen will be set free to be absorbed by the Water in the bottles. The Water will absorb about three times its own bulk of this Gas, and will possess its disagreeable smell. The Harrowgate, and other Waters, are natural compounds of this kind.

Observation. Water may be impregnated in the same way, by pouring diluted muriatic acid over sulphuret of potass, or soda.

CCCCXCI.

Hydro-Zincic Gas.

Pour diluted Sulphuric Acid over some broken Zinc in a retort; place the beak under a Pneumatic shelf, and receive the Gas which comes over, in jars. Here the Sulphuric Acid, in its action upon the Zinc, receives the aid of the Oxygen of the Water, by which the Metal is oxidised previous to its solution. The Hydrogen in consequence is set free; but before it leaves the retort, it combines with a portion of the Zinc in very minute particles; by which means it is converted into Hydro-zincic Gas.

CCCCXCII.

Arseniated Hydrogen Gas

Put 4 drams of Zinc Filings into a small retort with 2 drams of Filings of Arsenic; and pour over them 1 ounce of diluted Sulphuric Acid: if the beak be put under a bell-glass on the Pneumatic shelf. Arseniated Hydrogen Gas will ascend and displace the Water. Here the acid, in acting upon the Zinc, decomposes the Water used as a diluent; the Oxygen of which oxidises the Metal, whilst the Hydrogen is set free to unite with the Arsenic. This Gas burns with a very delicate bright flame.

CCCCXCIII.

Carburetted Hydrogen Gas.

Put some pieces of fresh made Charcoal into an earthen tube, and pass it through a furnace, as in Plate 11, in the same manner as for the production of Hydrogen Gas. Attach a retort containing Water, place a lamp underneath, and let it boil. To the other end of the tube attach a bent glass one connected with a bell-glass over Water. The steam of the Water will be decomposed in its passage by the Charcoal, and the Hydrogen combining with some of the Carbon, will form Carburetted Hydrogen Gas.

Observations. Here it is to be observed, that as the Gas in question may be combined with, or adulterated by carbonic acid gas, the water in the receiver should be saturated with newly burnt lime, to absorb it. This absorption will cause a milky appearance, being a precipitate of carbonate of lime.

The analogy existing between this gas and that produced from coal by dry distillation, has often been the means of confounding the properties of each. Coal gas is in fact a compound of several inflammable gases, and is never (as contained in the public gasometers for lighting the streets, &c.) in that state of purity, which would warrant us to conclude it to be carburetted hydrogen. It is generally termed so, however, because the latter gas is predominant in the gaseous mixture produced from coal. Mr. Accum thus distinguishes between the several varieties of coal gas.

"I have never met with any *coal gas*, consisting of *pure carburetted hydrogen.* It has always proved, in the cases where I had an opportunity of examining it, a mixture of carburetted hydrogen, carbonic oxide, and hydrogen gas, the proportions of which vary according to the nature of the coal and of the process. When the heat is applied suddenly, and when it amounts to a good red heat, the proportion of carburetted hydrogen is greatest, and when the heat is low, the portion of pure hydrogen is greatest. Olefiant gas and sulphuretted hydrogen are probably likewise present, though in small and variable quantity. There is another circumstance connected with this gas, which has not hitherto been noticed, but which must have some influence upon the light which it yields. Coal gas has always the very same smell as the oil or naphtha which coal yields when distilled; therefore, it obviously contains a certain portion of naphtha mixed with it, in the state of vapour. When naphtha is put in contact with a quantity of common air, or indeed of any gas whatever, a portion of it mixes with the gas, in the state of vapour, and communicates to it the peculiar smell by which it is distinguished. Gas thus contaminated by the vapour of naphtha is not easily purified. It may be allowed to remain in contact with water, or even passed through water, without losing any of the naphtha vapour. The quantity of this vapour contained in coal gas depends upon the temperature of the naphtha and gas, when placed in contact. At the temperature of 55° the bulk of air, when placed in contact with naphtha, is increased 3 per cent. I find that the specific gravity of vapour of naphtha is 2.26, that of common air being 1.00. From this, it will not be difficult to determine the quantity of naphtha with which coal gas is usually contaminated. One volume of vapour of naphtha, for complete combustion, requires rather more than 2.4 volumes, but not quite so much as 2.5 volumes of oxygen gas. As carburetted hydrogen gas, carbonic oxide, hydrogen, and olefiant gases, are all destitute of smell, and as coal gas has always a strong smell of naphtha from which it cannot be, or at least has never yet been deprived, I conceive that the presence of the vapour of naphtha in it will not admit of a doubt."

Dr. Thomson has discovered a new compound inflammable gas, and has called it, from the nature of its constitution, *hydro guretted carbonic oxide.* Its specific gravity is .913, that of common air being 1. It is not absorbed nor altered by water. It burns with a deep blue flame, and detonates when mixed with oxygen, and fired. It is a compound of oxygen, hydrogen, and carbon; Dr. Thomson considers it as being three volumes of carbonic oxide and one volume of hydrogen, condensed by chemical combination, into three volumes.

OBSERVATIONS ON THE PRODUCTION OF COAL GAS.

The mode of lighting streets, houses, &c. with gas from coal, is an invention of the nineteenth century. We all remember the dismal appearance of our most public streets previous to the year 1810; before that time, the light afforded by the street lamps hardly enabled the passenger to distinguish a watchman from a thief, or the pavement from the gutter. The case is now different, for the gas-lamps afford a light little inferior to day-light, and the streets are consequently divested of many terrors and disagreeables, formerly borne with, because they were inevitable.

The gas with which these lamps are supplied, is not generated on the spot, but in many cases, at a very great distance. For the supply of several districts in London and other towns, the gasometer and other apparatus for producing, and purifying gas from coals, are situated in some convenient place, from whence the gas is conveyed in metallic pipes to the lamps where it is destined to undergo combustion.

Plate 16 exhibits an apparatus for the preparation of gas from coal. In this case only one retort is used; but in the larger apparatus, used for public accommodation (see same Plate), five retorts are heated by one fire, and of course save a considerable expense of fuel. These retorts are all made of cast iron, and are generally of an eliptical shape, as exhibited in the Plate; but a recent alteration of shape has taken place in some gas establishments: this consists in using retorts of an oblong form, but convex on their under sides. Plate 17 represents the inside of a coal-gas establishment, conducted on a large scale, in Brick-lane, Spitalfields, London. The workmen are in the act of raking out the coke from the retorts, and supplying them with fresh coals for distillation.

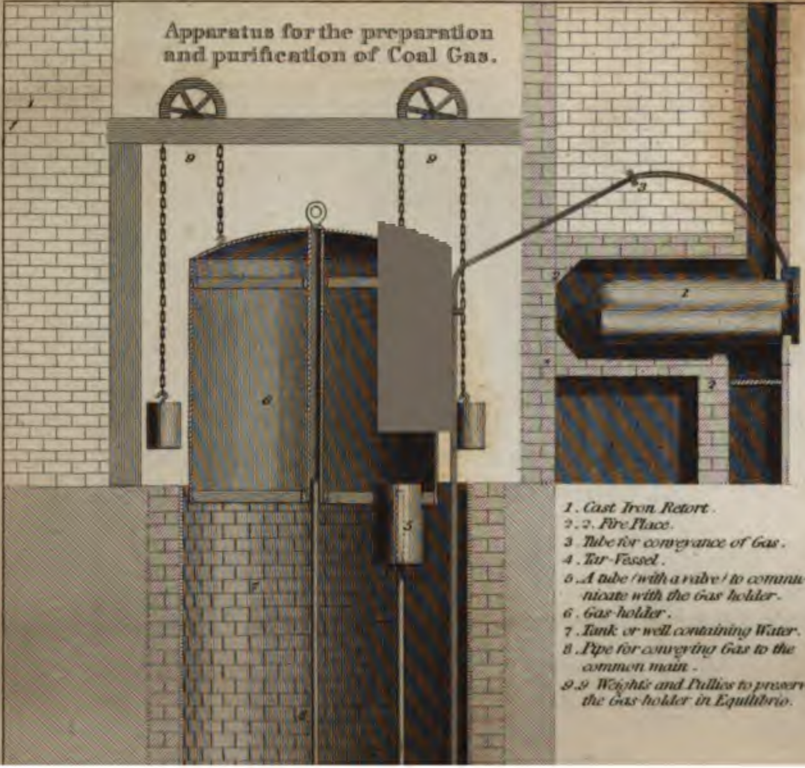
We shall here describe the mode of preparing gas by the apparatus exhibited in the Plates referred to. The coals are introduced into the cast-iron retort or cylinder, which is placed on its side in the furnace. The retort is then closed by an air-tight metallic plate, which is fastened to it by bolts and nut-screws. The lower part of the retort is preserved from the action of the fire by a larger half cylinder of cast iron, inclosed in brick-work, placed at some distance below it; by which means, the heat is more equally distributed to the pit-coal.

A cast-iron pipe proceeds from the upper side of this cylinder to a cast-iron receiver, which is situated at the bottom of the well in which the gasometer rises and falls; in this receiver the tar and other condensible products are collected, and are extracted from time to time, by means of a pump affixed to it.

From the top of this receiver proceeds another iron pipe, which reaches to the surface of the water in the well, but which is inserted into an air-holder of about 18 inches in diameter, and two feet long, made of iron. The lower part of this air-holder

PLATE XVI.

Apparatus for the preparation and purification of Coal Gas.



1. Cast Iron Retort.
2. 2. Fire Place.
3. Tube for conveyance of Gas.
4. Tar-Vessel.
5. A tube (with a valve) to communicate with the Gas holder.
6. Gas-holder.
7. Tank or well containing Water.
8. Pipe for conveying Gas to the common main.
9. 9. Weights and Pullies to preserve the Gas-holder in Equilibrio.

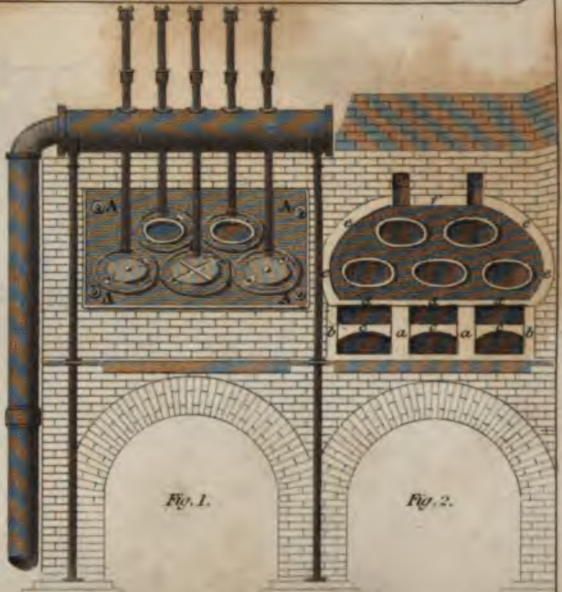


Fig. 1. Fig. 2.

Malam's Plan of heating 5 Gas-retorts by one Furnace.

1. Front-view of Retorts &c. Complete.
A.A.A.A. Retorts resting on a cast-iron plate secured by bolts so as to prevent disturbance to the brick-work in replacing the Retorts.
2. Section of Retorts furnace &c.
a.a.b.b. Fire lumps placed edgewise.
c.c.c. Arches over the fire places.
d.d.d. Fire tiles forming a bridge from one side of the Oven to the other
e.e.f.e.e. Section of Oven.

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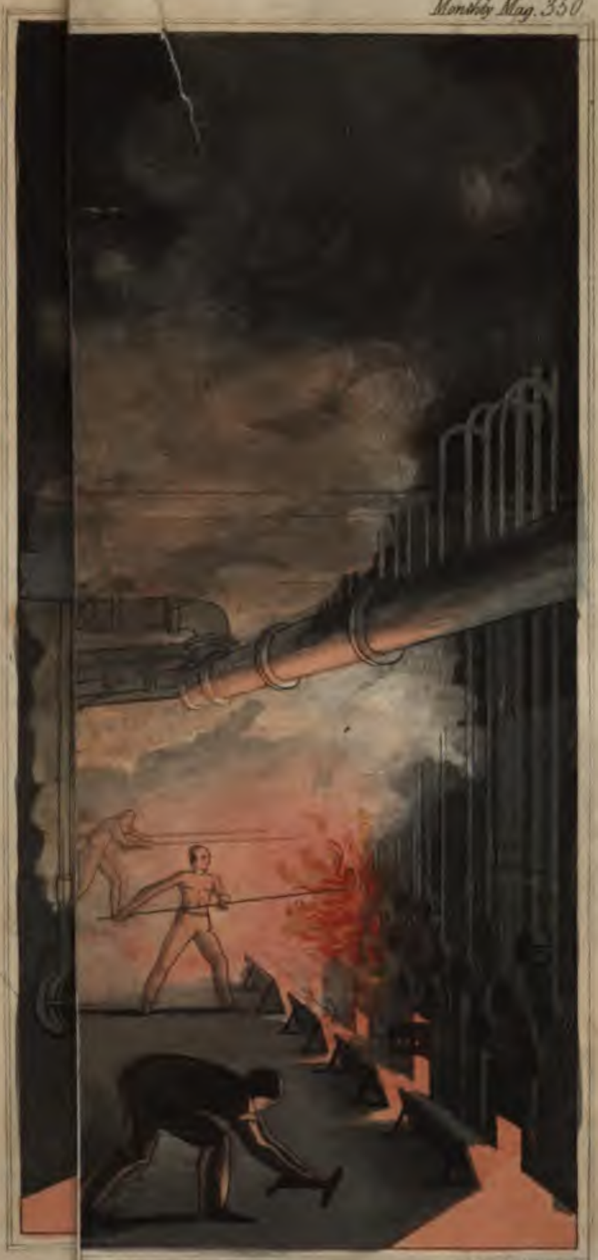

W. Read, Sculp.

ent, Brick Lane.

is pierced with holes, which serve a double purpose, first to divide the gas into several small streams, and thus to render it purer by washing it as it passes through the water; and secondly, it serves as a reservoir of gas, from whence the tar receiver, connecting tubes, and even the retort itself, may be filled with gas whenever an absorption takes place, by the retort being cooled, or otherwise. The gas is discharged from this air-holder into the gasometer, which is suspended over the well, and rises and falls therein, being balanced by two weights passing over pullies. This gasometer is made of wrought iron plates, luted in the seams, so as to be air-tight, and well painted both within and without; it has an iron pipe made fast in the centre by means of two sets of stays, one at the bottom of the gasometer, and the other at the top. An upright pipe, fixed in the centre of the well, passes up the central pipe of the gasometer when it is depressed in the well. The gas is pressed out of the gasometer through a row of holes at the very top of the central pipe, into that pipe, whence it passes into the centre pipe of the well, which is continued across the well, and up the side, and from thence is branched out to the lamps. Each of these lamps will consume about six cubic feet of gas in an hour. They are composed of two concentric tubes closed at the bottom by an annular plate; the gas is introduced between them by a stop-cock in the side, and emitted for combustion, by a row of holes in the annular plate which connects the two tubes at the top. To assist the combustion, the current of air that passes through the inner tube, is directed against the flame by a button at the end of a wire, which slides up and down the inner tube; and thus the button can be placed at any required distance from the upper orifice of the tube. This current is also determined from the flame, by the upper orifice of the inner tube being enlarged. A glass chimney is also used, which is supported on an annular plate, pierced with holes to admit the air to the external surface of the flame.

As soon as coal gas came to be extensively applied to the purposes of street illumination, and to domestic use as a substitute for lamps and candles; it became an object of great importance to the proprietors and managers of the different gas works, to ascertain with accuracy, the quantity of gas expended, in proportion to the number of jets or burners made use of.

The essential conditions of any apparatus for this purpose are, that the pressure on the gas while passing through the measurer shall at all times be uniform; and that it shall register truly when that pressure is very small, and when the current of gas is very feeble.

The first gas-meter was constructed by Mr. Clegg, and is secured to the inventor by a patent. It consists, essentially, of a cylinder, divided into cells, inclosed and revolving in an outer cylinder, which is less than half filled with water. The gas enters laterally through the perforated axle, into that cell of the inner cylinder which happens to be nearest the surface of the water. It displaces the fluid from this cell, consequently destroys the equilibrium of the cylinder, and communicates to it a rotatory

One Chaldron of	*Cubic ft. of gas*
"Scotch cannel coal produces	19,890
Lancashire Wigan coal	19,608
Yorkshire cannel coal (Wakefield)	18,860
Staffordshire coal,	
First variety	9,748
Second variety	10,223
Third variety	10,866
Fourth variety	9,796
Gloucestershire coal,	
First variety (Forest of Dean, High Delph)	16,584
Second variety (Low Delph)	12,852
Third variety (Middle Delph)	12,096
Newcastle coal,	
First variety (Hartley)	16,120
Second variety (Cowper's High Main)	15,876
Third variety (Tanfield Moor)	16,920
Fourth variety (Pontops)	15,112"

"*Second class of Coals.*—Those which contain a less proportion of bitumen, and more charcoal, comprehend the varieties of the second class.

"Coals of the second class do not burn with so bright a flame as the former. The flame of these coals is of a yellowish tinge. After lying some time on the fire, they become soft and swell: they then cake, and produce tubercles, from whence issue small jets of flame. When coals of this kind are burnt in an open grate, the passage of the air through them is prevented by the top of the fire caking and closely adhering. The consequence which follows is this: the lower part of the coal contained in the grate is consumed, and leaves a hollow, whence, if the upper part were not occasionally broken, the fire would go out. These coals produce a smaller proportion of ashes than coals of the first class. They are of a greyish or reddish colour, according to the quality of the earthy parts of which the coal may be constituted. They produce hard grey cinders, which, being burnt over again with fresh coals, produce a very strong heat. The colour of the flame produced from this class of coal, is not so white and brilliant as that emitted by cannel-coal, and those of similar properties; and that portion of it which is given out, after the bitumen it contains is disengaged, is of a pale blue colour. The gas which they produce, during this part of the process of combustion, is a mixture of oxide of carbon, hydrogen, and carbonic acid. The coke produced from this class of coal, during the process of generating gas therefrom, when carbonization is properly carried on, is well adapted for domestic and culinary purposes; and when such coal is manufactured into coke in the ordinary way, it is calculated to be used in the furnaces of iron-founders, and for other metallurgical operations. Coals of this class are, in the market, denominated *strong burning coals.* The coals which may be named under it, are Bewicke and Crastor's Wallsend, Bewicke's Wallsend, Russel's Wallsend

Bell's Wallsend, Brown's Wallsend, Wear's Wallsend, Manor Wallsend, Wellington Main, Temple Main, Heaton Main, Killingworth Main, Headsworth, Hepburn Seam, Hutton Seam, and Nesham. Smiths prefer the smaller kind of this class of coals before any other, in consequence of its affording the greatest heat, the best cinders, and standing a strong blast. Swansea coals may be considered as belonging to this class. Some of the varieties contain pyrites, others thin layers of lime-stone and shells; these are found amongst the ashes they afford as slates and stones. When submitted to distillation, a greater heat is required than is necessary for decomposing coals of the first class; but the gas which they afford is easily purified, and is generally better adapted for use than that obtained from coals of the first class. The aqueous fluid which passes over, during the process, contains sulphate, carbonate, and hydrosulphuret of ammonia. When coals of this kind are mixed with those of the first class, in the proportion of two-thirds of the former with one-third of the latter, an excellent fuel is thereby formed; and if, in making the mixture, the proportion of coals of the first class be increased, the fuel will be more easily managed, and will burn with greater cheerfulness; but then its durability will decrease in a like proportion.

One Chaldron contains	*Cubic ft. of Gas.*
Newcastle coal,	
First variety (Russell's Wallsend)	16,876
Second variety (Bewick and Craister's Wallsend)	16,897
Third variety (Heaton Main)	15,876
Fourth variety (Killingsworth Main)	15,312
Fifth variety (Benton Main)	14,812
Sixth variety (Brown's Wallsend)	13,600
Seventh variety (Manor Main)	12,548
Eighth variety (Bleyth)	12,096
Ninth variety (Burdon Main)	13,608
Tenth variety (Wear's Wallsend)	14,112
Eleventh variety (Eden Main)	9,600
Twelfth variety (Primrose Main)	8,348

Third class of Coals.—The third class are such as contain very little bitumen, but are chiefly composed of charcoal, chemically combined with different earths.

Coals of this class require a very high temperature to bring them into ignition; they do not burn till wholly ignited; and then some of the varieties produce a very weak flame; others neither yield flame nor smoke, and merely produce a red heat like that which is generated by charcoal, when under combustion. They contain a very considerable portion of charcoal; they produce only a small quantity of ashes, but these are generally very heavy. When distilled in close vessels, they do not produce much tar; and that portion which is disengaged, comes over in a state nearly resembling melted pitch. Under that process, they also yield a gaseous fluid composed of gaseous oxide of carbon, hydrogen gas, and a considerable portion of sulphuretted hydrogen. Considering the nature of the different varieties of this class of coals, it can hardly be expected, that it would be profitable to use them for generating coal gas. The Kilkenny, Welsh, and Stone coal, are varieties forming this class.

One Chaldron contains	*Cubic feet of Gas.*
Welch coal,	
First variety, from Tramsaren, near Kidwelly	2,116
Second variety, from the yard vein at the same place	1,656
Third variety, from Blenew, near Llandillo	1,416
Fourth variety, from Rhos, near Ponty Barren	1,272
Fifth variety, from the vale of Gwendrath	1,292
Sixth variety, from ditto	1,486

Mr. Brande states that the produce of one chaldron of good coals, will be,

	£.	*s.*	*d.*
In coke, 1¼ chaldron, at 31*s.*	1	18	9
In tar, 12 gallons, at 10*d.*	0	10	0
Ammoniacal liquor, 18 gallons, at 6*d.*	0	9	0
Gas, 20,000 feet, at 1*l.* for 1,252 feet	16	2	3
	£. 19	0	0

By Mr. Clegg's improvements in the production of gas, 25,000 cubic feet are generated from one chaldron of Wallsend Coals, without the formation, either of tar or ammoniacal liquor, being 15,000 cubic feet more than was formerly produced. The coal is introduced, by a mechanical process, in strata not exceeding half an inch in thickness. In this way, the retorts are kept at an uniform heat, and the coal is completely and rapidly decomposed, is that the whole of the hydrogen combines with the charcoal, constituting olefiant gas; and the matter which usually escaped in the form of tar and ammoniacal liquor is perfectly decomposed. The expense of producing 50,000 cubic feet of gas in twenty-four hours on the old plan is 3,817*l.*, upon the new plan 1,123*l.*; and the expense of producing an equal quantity of light from oil 19,010*l.*

If the tar which is obtained from the distillation of coal for gas-light be made into a paste with saw-dust, and put into the retort, it will yield gas in greater abundance than the best coal, and of an excellent quality.

Messrs. Taylor and Martineau are in the habit of constructing apparatus for the production of gas for illumination from oil. A very handsome and convenient apparatus of this sort has been erected in the laboratory of the Apothecaries Company, Blackfriars, London.

For the purification of coal gas from sulphur and other substances by which it is apt to become contaminated, various methods have been tried and adopted. All these methods depend upon the affinity which exists between the sulphur, &c. and those substances used in the purification. The first of these inventions which we shall notice, is that of Mr. Palmer.

"The gas (says Mr. P.) may be made by any of the usual processes, and is to be conveyed in pipes to a condensor or refrigeratory, to deprive it of its tar, ammoniacal liquor, and condensible ingredients. From thence it is to be conveyed to one of my purifiers, which consists of a vessel of any form, and made of cast iron, or any other material which will stand the action of heat. This purifier is to be kept moderately red hot while in action; to accomplish which, it may be set in the same furnace as the retorts, or heated by a separate fire (which will be governed by the nature and extent of the concern), so as to be visibly red by day-light. It must be understood that I mention this temperature as being sufficient, although a higher one will not be detrimental to the process, but will destroy the purifying vessel more rapidly.

"This purifying vessel is to be nearly filled with the fragments or refuse clippings of sheet iron, tinned iron plates, or any oxide of iron at a minimum of oxidation, such as common clay or argillaceous iron ore, or finery cinders, or black oxide of iron; and, when so filled and heated, the gas must pass through it. This will effect a partial decomposition of the sulphuretted hydrogen, to complete which it must pass into a box or cistern of cold water. The pipe which conveys the gas into the box or cistern, should just dip into the water, and a pipe at the top of the cistern must communicate with the gasometer, into which the gas will flow perfectly pure, and can then be distributed and burnt as usual. The operation of this method of purification must be obvious to those who are acquainted with chemistry; for it will be readily observed, that the sulphuretted hydrogen contained in the gas will be decomposed, by the action of heat and the substances used, into hydrogen and sulphuric acid, whilst, at the same time, no sulphurous acid gas can escape the agents to which the crude gas is exposed.

"Whenever it is ascertained, by smell or chemical tests, that the gas does not come over completely purified, it will determine, that the contents of the purifier are saturated, and the gas must then be turned off by an arrangement of cocks or valves to another purifier, similar, in every respect, to the one described; observing, that when one of the purifiers is thrown out of action, it need not have its contents removed, but merely exposed to the action of the atmosphere by the removal of its covers; and as it is still kept red-hot, it will, before the purifier just named becomes saturated, be again competent to purify the gas. The purifier should not be worked longer at one time than from six to twelve hours each, which time must be governed by the quantity of gas passed through them. This method of proceeding must be invariably observed with each purifier, working them alternately until it is ascertained that the metallic iron is rendered useless; in which case the purifier must be discharged of its contents, and filled with fresh.

"The pipes connected with the purifiers for the admission and discharge of the gas should have an immediate fall, so as to prevent the condensible products from returning back into the purifiers;

for this would destroy the play of chemical affinities between the sulphuretted hydrogen and the metallic iron, by covering its surface with a carbonaceous crust."

The next method of purifying is, by using fresh burnt earths to combine with the sulphur. It was invented by Mr. Haddock.

In the first place, he charges the retort with a quantity of pit-coal proportionate to the size thereof, and then adds thereto one-eighth part, by weight, of well burnt fresh lime, baryta, strontia, or any other alkaline earth or substance, having a strong affinity for sulphur, such substance being first perfectly freed from carbonic acid, but he prefers lime, as being the cheapest, and, in his opinion, best adapted to the purpose. He next causes the products emitted from the retort to pass through a red-hot cylinder, or other shaped vessel, filled with well burnt fresh lime, free from carbonic acid, or with any other substance or substances free from carbonic acid, oxygen, ammonia, or sulphur, and not possessing the property of giving an injurious quality to carburetted hydrogen gas. He introduces such lime, or other substance or substances, to check the too rapid progress of the volatile ingredients emitted from the retort, in order that any yet undecomposed petroleum may be converted into carburetted hydrogen.

The red-hot cylinder, or other shaped vessel, must be immediately connected with the retort, so as to prevent, as much as possible, the condensation of any petroleum. He then causes the gas to be passed through a washer of water, acidulated with sulphuric acid, or any acidulated water capable of fixing ammonia; and he afterwards continues the process in the manner hitherto in practice.

The last method we shall mention is that of Mr. Grafton, He says:—

"The material to be applied for the purpose of taking up the sulphuretted hydrogen and carbonic acid gases, is a compound of lime with pot or pearl ashes and charcoal or coke, which is formed by pouring a strongly impregnated solution of pot or pearl ashes in water upon recently burnt and unslacked lime, the quantity of the solution required being so much as will slack the lime, or cause it to fall to powder. This done, add dry pot or pearl-ashes about one-fifth of the whole weight of the lime, and also about one-fourth of the charcoal or coke broken into small pieces, the whole to be perfectly mixed together, which composition is to form the absorbent or purifying stratum.

"The purifying vessel is divided into several upper and lower compartments, the gas being intended to pass from one to another through the stratum of prepared lime as above compounded. This is spread upon a wire gauze web, extended horizontally through the middle of the vessel. The gas from the retorts passing through the main is introduced into the purifying vessel at one end, when having filled the first lower compartment, it rises through the stratum of lime, &c. extended over it into the upper compartment, having undergone an operation similar to filtering; by which a chemical union takes place between the slacked lime and the impure parts of the gas. From the upper compartment of the gas descends again through the stratum of lime into the second lower compartment, and from thence rises again through the purifying stratum into the second upper compartment, and so on; ascending and descending through strata of lime until it reaches the last chamber, having, by this operation, become purified, whence by a pipe it is conveyed into the gas-holder.

"The apparatus above alluded to, consists of a long box, having several partitions; and at each end of the box on the outside, is attached a cylindrical roller, over which is extended an endless web, or band, made of wire gauze: this endless web lies upon, and covers the top of the box lengthwise, passing under it; and upon its upper side over the box is distributed the layer or stratum of he above purifying compound.

"This apparatus is inclosed within another box or case, in the upper part of which several sliders are placed, which shut down close upon the wire gauze, at parts intervening between the partitions of the box below; forming the upper compartments above alluded to: between this and the lower compartments, the stratum or layer of lime, &c. is extended upon the wire gauze.

"There are also roller brushes under the wire gauze web, to cleanse it from any coagulated portions of the lime which may possibly adhere after the saturated stratum has been removed."

CCCCXCIV.

PHOSPHURETTED HYDROGEN GAS.

Put into a small retort half a dram of Phosphorus in small pieces, and a dram of Zinc Filings. Pour over these, 3 drams of Sulphuric Acid diluted with 6 drams of Water. Put the beak of the retort under a bell-glass in a Pneumatic trough: Phosphuretted Hydrogen Gas ascending will displace the Water, and fill the glass. Several glasses may be filled from this quantity: one of these glasses should have a stop-cock, by which bladders may be filled, or by which it may be allowed to issue for combustion in Atmospheric air. In this experiment, the Zinc and Acid decompose the water, whose Hydrogen being set free, combines with the Phosphorus, and both are evolved in the gaseous form.

Observations. The preparation of this gas may be varied by putting 5 grains of phosphorus, cut small, and 10 grains of zinc filings into a wine-glass, and by pouring over them half a dram of sulphuric acid diluted by a dram of water. Globules of phosphuretted hydrogen gas will ascend to the surface, and will inflame as soon as they come in contact with the air.

This experiment may be vareid by holding the beak of the retort in a perpendicular position, and allowing the gas to ascend and combine with the atmospheric air. In doing this, a continued stream of fire will be seen to issue from the liquid below. This is an interesting experiment. To prevent inconvenience, the retort may be placed in a basin, in an upright position, and the ingredients may thus be poured in without inconvenience.

A still further variation in the mode of combination between phosphorus and hydrogen, is as follows :—

Prepare a jar of hydrogen gas over mercury, by the decomposition of water by sulphuric acid and iron filings. Pass two or three small bits of phosphorus up through the mercury, that they may remain in contact with the hydrogen gas. In the course of ten or twelve hours the combination will be complete.

CCCCXCV.

SILICATED FLUORIC GAS.

Pulverise an ounce of Fluate of Lime (Fluor Spar), and half an ounce of Glass; put these into an earthen or glass retort, and pour over them an ounce of Sulphuric Acid: receive the Gas in glass jars over Mercury.—Water absorbs so much of this Gas, that it can hardly be collected over it.—This Gas being already saturated with Silex from the powdered Glass, has no action on any glass vessels which may receive it, so that it may be kept in them for any length of time.

CCCCXCVI.

FLUO-BORIC GAS.

Put into a tubulated retort 4 drams of pulverised Fluate of Lime, 2 drams of dry Boracic Acid, and 3 ounces of Sulphuric Acid; give them a tolerable heat: the Gas which comes over will be the Fluo-Boric, which does not act upon Glass, and may be condensed (as it is remarkably absorbable by Water) in the receiver, containing a few ounces of Water at the bottom, and surrounded by pounded Ice, or a freezing mixture: if the Water has absorbed sufficient, the whole will be of an oily consistence like Sulphuric Acid. It may be preserved in a stopped bottle. In the formation of this substance, the Sulphuric Acid separates the Lime from its combination, forming Sulphate of Lime: the two Acids accordingly combine together, and are driven off by the heat in a state of Gas.

CHAPTER XI.

EXPERIMENTS ON RESPIRATION.

CCCCXCVII.

Chlorine Gas

Does not support Animal Life.

Place a mouse or other small animal, under a jar of Chlorine gas; or drop it into one from the aperture at the top of a jar filled with it. The animal will instantly expire.*

CCCCXCVIII.

Hydrogen Gas

Does not support Animal Life.

Immerse a mouse or small bird in a jar of Hydrogen gas; the animal will instantly die from suffocation, and the want of its regular respirable nourishment.

Observation. It has been found, that if a person speaks immediately after breathing hydrogen gas, his voice for a few moments suffers a change, but this soon goes off.

CCCCXCIX.

Nitrogen Gas

Does not support Animal Life.

If a mouse or sparrow be dropped into a jar of Nitrogen gas, it will fall down exhausted, and gasping for breath:—extinction of life will immediately follow.

D.

Nitrous Oxide Gas

Does not long support Animal Life.

Prepare a jar of this gas, and immerse in it a mouse or other small animal; at first it will appear lively, but afterwards very uneasy and languishing, and life will quickly become extinct.

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* It is hoped that some of the following experiments will not be repeated through mere wantonness.

DI.

DESTRUCTION OF ANIMAL LIFE BY SULPHUROUS ACID GAS.

If a mouse or other small animal be immersed in a jar of Sulphurous Acid Gas, it will instantly expire. There are few gases more deleterious to animal life than this, and too much care cannot be taken not to breathe an atmosphere charged with it even in a small degree.

Observations. When the smell of sulphur prevails in a room from the burning of pyrites (sulphuret of iron), coke, &c.; this is nothing less than the sulphur combined with the oxygen of the atmosphere, forming sulphurous acid gas. In such cases, it is proper to open the door and windows, or to leave the room. A burning sulphur match emits sulphurous acid gas; and if by accident, one of these be held under the nose, a sense of suffocation will be felt.

DII.

INABILITY OF CARBONIC ACID GAS

To support Animal Existence.

If a mouse be dropped into a jar containing Carbonic Acid gas, it will expire in two or three seconds. In this way Butterflies, &c. may be preserved for Cabinets.

Observations. Carbonic acid gas is the choke-damp of mines. It is that gas which escapes during the fermentation of porter, &c. and men who have held their noses to the bung hole of casks whilst this process has been going on, have been known to fall dead from suffocation, or from the passage of a portion of the gas into the lungs. It is also that deleterious gas called *charcoal fumes*, which, unfortunately, so many artizans and manufacturers are condemned to inhale, by burning charcoal fires in close workshops. Nothing can be more evident than that carbonic acid gas will be generated when charcoal is burnt in common air, from whence it has a continued supply of oxygen. It is not the hard work of the manufacturer that destroys his constitution, at a time when he should be most robust and healthy; but the respiration of foul air, with scanty and perhaps bad nourishment. Even within a few weeks, the newspapers relate that two female servants in Hertfordshire, having incautiously placed in their bed-room, a large brazier containing lighted charcoal, were next morning found dead in bed!!

To obviate the respiration of carbonic acid gas, if charcoal fires *must* be used, we would suggest, in addition to other methods of ventilation and purification of the air, the absorption of this gas by lime water poured into shallow vessels. These should remain *on the floor* of the workshop, and the lime water should be daily changed. The pure lime will absorb the gas, and be converted into carbonate of lime.

This gas, from its gravity, sinks in the atmosphere; hence it is generally found at the bottom of old wells, &c. &c. and may be known to exist in them, by the extinction of a lighted candle. The Grotto of Dogs in Italy, has its name from the practice of putting dogs into it, who immediately fall down from suffocation. They are afterwards recovered by immersion in cold water, and answer the same purpose for the *gratification* of the next company of visitors. The carbonic acid gas in this cavern will not have the same effect upon man, because from its gravity it keeps its station at the bottom, reaching no higher than the knee ; the rest being occupied by common air: consequently it will have that effect upon the respiration of a dog or other small animal, that it cannot have on a human being.

DIII.

NITROUS GAS

Does not support Animal Life.

Confine a mouse or other small animal in a jar of Nitrous Gas: life will immediately become extinct.

DIV.

ATMOSPHERIC AIR

Supports Animal Life, only while it contains Oxygen.

Immerse a mouse in a jar of Atmospheric Air; it will at first give no signs of uneasiness; but as its respiration proceeds, and the Oxygen is consumed, (the Atmospheric Air in the glass being loaded with Carbonic Acid Gas from the lungs;) the animal will gradually become faint, and if kept in it much longer, *will die.*

Observations. It is well known, from the mutual respiration of plants and animals, and from other causes, that the wholesome qualities of the atmosphere are kept up by the oxygen and nitrogen, which are its component parts, being in due proportion. If the atmosphere were composed of nitrogen alone, no animal (according to the present construction of its body) could live in it for an instant. On the contrary, if oxygen alone composed the atmosphere, animals would very shortly die from its effect upon the blood, in causing a hurried respiration, and quickening the pulse. But by a proper combination of 22 parts of oxygen with 78 of nitrogen, the atmosphere is adapted for respiration.

DV.

OXYGEN GAS

Is the best Supporter of Animal Life.

Let two jars be placed on a table; the one containing Oxygen gas, and the other pure Atmospheric Air. Into each of these, let a mouse be dropped. The animal immersed in the Oxygen will live four times as long as that in the jar of Atmospheric Air.

Observation. The cause of this phenomenon is, that as the atmospheric air contains nitrogen gas as well as oxygen, it cannot answer the purpose of respiration so long as an equal volume of pure oxygen.

DVI.

OXYGEN GAS

Causes the red Colour of the Blood.

Withdraw quickly the cork of a phial containing Oxygen Gas, and pour into it 3 or 4 drams of venous blood; cork it again quickly, and shake the phial. The blood will now become of a vermillion hue, and like that drawn from an artery. A similar effect will take place if venous blood is thrown up by means of a warm syringe into a jar of Oxygen Gas placed over Mercury. These experiments correspond with the theory of the oxygenation of the blood of animals, by decomposition of the Atmospheric Air inhaled by the lungs.

DVII.

FURTHER PROOF THAT OXYGEN GAS

Causes the red Colour of the Blood.

Procure some dark coloured blood, and place a deep saucer containing it, on water or mercury in a pneumatic trough; and invert a jar over it. Leave the whole undisturbed until the surface is perfectly red, from the decomposition of the Atmospheric Air in the jar. Now withdraw the cork at the top, and immerse a lighted taper; the flame will be very quickly extinguished, owing to the absence of Oxygen, or any other supporter of combustion: nothing but Nitrogen and Carbonic Acid Gas remaining in the jar.

Observations. If instead of atmospheric air, a jar of oxygen gas be quickly inverted over the saucer, in a mercurial trough, the vermillion hue will be sooner acquired by the blood, and the loss of oxygen (occasioned by its absorption or decomposition by the blood) will be replaced by the ascent of the mercury in the jar. If, on the contrary, arterial blood be exposed in a similar way to the action of confined carbonic acid, its red colour will be changed to that of venous blood (purple). It would be perhaps worth trying what effect other gases would have on arterial blood, by a similar exposure.

The colour of blood has been generally supposed to depend on iron but some experiments by Vauquelin have demonstrated the erroneous nature of this opinion, and have proved, that a colouring matter may be drawn from the blood, in which the most delicate test cannot discover the smallest trace of iron. The blood, according to Vauquelin's experiments, is composed of albumen; fibrine; colouring matter; and a fat and mild oil. The constant presence of the latter of these, however, in the blood of man, requires the authority of further experiments.

Although oxygen seems in general to be absolutely necessary to preserve vitality; it is stated by M. Biot, that the insects called Blaps and Tenebrions, may be left in the rarest vacuum that can be made by an air pump, for several days, without appearing to suffer any inconvenience. Oxygen gas has been used with great advantage in cases of suspended animation from drowning, &c; also for the cure of some nervous disorders, &c. There is an apparatus for the administration of this gas, which may in any quantity be mixed with common air, and inhaled by the patient. When breathed, the pulse becomes considerably accelerated.

Dr. Siliman's American Journal of Science contains the following case of respiration of oxygen gas. A young lady, apparently in the last stages of decline, and supposed to be affected with hydrothorax, was pronounced beyond the reach of ordinary medical aid. It was determined to administer oxygen gas. The gas was obtained from nitrate of potass (saltpetre), not because it was the best process, but because it could be obtained in the place, and because a common fire would serve for its extrication. The gas obtained had, of course, a variable mixture of nitrogen or azote, and probably, on an average, might not be purer than nearly the reversed proportions of the atmosphere; that is, seventy to eighty per cent. of oxygen to twenty or thirty of nitrogen: and it is worthy of observation, whether this circumstance might not have influenced the result. Contrary to expectation, the gas was skilfully prepared and perseveringly used. From the first, the difficulty of breathing, and other oppressive affections, were relieved: the young lady grew rapidly better; and in a few weeks entirely recovered her health.

DVIII.

CARBONIC ACID GAS EVOLVED FROM THE LUNGS

In Respiration.

If a person breathes repeatedly into a phial, or other vessel containing pure Lime-water; the clear liquid will become quite turbid. This is caused by the combination of the pure Lime with the Carbonic Acid proceeding from the Lungs during each expiration. The Milky appearance is owing to the insolubility of the Carbonate of Lime.

Observation. The expiration of carbonic acid gas from the lungs is owing to a decomposition which the atmospheric air undergoes, whilst acting on the blood. The blood returning by the veins from all parts of the body, is loaded with carbonaceous matter, and is consequently of a *purple* colour. The oxygen of the common air, combining with the carbon, forms carbonic acid, which flies off, and from its specific gravity descends towards the earth. The blood is accordingly changed to a *vermillion* colour, and is ready for fresh emission by the contractile power of the heart. Meantime, the nitrogen of the common air inhaled is set free, and will be exhaled with the carbonic acid gas. The nitrogen gas being lighter than either atmospheric air or carbonic acid gas, ascends, whilst the latter descends, thus making room for a fresh inspiration of atmospheric air, which enters between the two currents of the before mentioned gases.

DIX.

INTOXICATING EFFECTS OF NITROUS OXIDE GAS.

Fill a bladder, having a tube and stop-cock, with this gas. If the mouth be applied to the tube after the expiration of as much air from the lungs as possible; and this gas be repeatedly inhaled instead; a strange but very pleasant sensation will pervade the whole body: this will be accompanied by warmth at the chest, and giddiness. The eyes of the person who has inhaled it, will roll about wildly, and he will have every symptom of intoxication: still this intoxication will be different from that produced by ardent spirits. For the experimentalist will, as it were, be so much elated, as to give way to all manner of extravagant and violent actions and gestures; such as running, leaping, wrestling, boxing, dancing, reciting, whooping and holloaing.

Observation. It is rather singular that many have evinced at this time, what were their general propensities at others. Some, for instance, will recite plays, whilst others are ready to knock the by-standers down. The experiment of inhaling this gas, should be performed in a field, or in a large room, without furniture, that nothing may impede the extravagant motions of the *pro tempore* madman.

DX.

EFFECTS OF CARBONIC OXIDE ON RESPIRATION.

Professor Higgins of Dublin wishing to compare the effects of Carbonic Oxide with those of the Nitrous Oxide, by inspiration, procured some for that purpose. Having exhausted his lungs of Atmospheric Air, he made three or four deep inspirations of the gas. The effects were an inconceivably sudden deprivation of sense and volition. He fell supine and motionless on the floor, and continued in a state of total insensibility for nearly half an hour, almost lifeless; pulsation being nearly extinct. Several medical gentlemen being present, to witness the experiment, various means were used for his restoration, but without success. At last, the introduction of Oxygen Gas by compression into the lungs, was suggested. A very rapid return of animation ensued, though accompanied by convulsive agitations, excessive headache, and quick irregular pulsation; and for some time afterwards, total blindness, extreme sickness, and vertigo, with alternations of heat and shivering cold, were painfully experienced. This state was succeeded by an unconquerable propensity to sleep, which was broken and feverish. An emetic of tartarized antimony finally removed those alarming symptoms, and the only unpleasant effects felt on the ensuing day, were those occasioned by the fall. In the confusion, the quantity of gas respired, or the change it underwent in the lungs, was unobserved. And although this experiment is too hazardous for repetition, still it is a proof of the efficacy of oxygen gas, which may arise in cases of suspended animation proceeding from choke damp, &c. &c. &c. Another gentleman had respired the gas a few minutes previous to Prof. Higgins, and suffered much from the attempt.

DXI.

Extinction of Life by Carburetted Hydrogen Gas.

Prepare a jar of Carburetted Hydrogen Gas, and immerse in it a mouse or other small animal: life will immediately become extinct.

CHAPTER XII.

EXPERIMENTS ON COMBUSTION.

General Observations.

COMBUSTION is the decomposition of a body at an elevated temperature, with the evolution of Light and Heat. Some suppose Combustion to be the effect of a certain degree of motion of the particles of Combustible bodies; and that Flame is merely a transparency, or luminosity, of these particles when they are thrown to certain distances with considerable velocity.

The generally received theory of Combustion is, (considering Heat and Light to be bodies in themselves,) that the Oxygen Gas of the Atmosphere consists of Oxygen and Heat; and the Hydrogen and Carbon of Combustibles, (such as Coals, Wood, Oil, and Spirits,) consist of certain bases, or radicals, with Light: that, in common cases of Combustion, Decomposition of both takes place; the result of which is, that the Oxygen, or base of the Gas, combines with the base of the combustible, to form an Oxide, or the ashes; whilst the Caloric of the Gas, and the light of the combustible, are evolved in the state of flame.

The latter Theory is considerably strengthened by the well-known Chemical Law, that in most cases of Combustion there must be a Combustible and Supporter of Combustion present. A Candle, Wood, Coals, or the combustible substance, will not burn unless common Air, or some other supporter of Combustion be in contact with it.

The Supporters at present known, are four—Oxygen, Chlorine, Iodine, and Fluorine. It is not necessary that these should be in a state of purity; for although combined with other substances, they will readily be given out to the burning body, if their affinity for the latter be greater than for the former. Thus, in common Combustion, the affinity (or tendency to combine) of the Oxygen of the Atmosphere for the *heated* Hydrogen and Carbon of a Candle, is greater than for the Nitrogen with which it formerly existed in the state of Atmospheric Air. There are, however, many anomalous causes of Combustion, (as will be seen by some Experiments towards the end of the 14th Chapter,) in which no acknowledged supporter seems to be present. The act of Combustion in these cases, must be induced by some cause of a different nature to that which takes place in common Combustion.

Flame is supposed to be a hollow film, or elliptical bubble, filled with volatile matter, the surface of which is formed where the vapour unites with the Oxygen of the Atmosphere. Mr. Porret discovered, that the luminous portion is surrounded by a Flame, nearly invisible, which produces Heat: the blue bottom is caused by a low temperature. Flame being transparent, a long wick merely intercepts the light of the opposite side of a Candle.

When pure gaseous matter burns, the light is very feeble, the density of flame being proportional to the quantity of solid Charcoal, first deposited, and afterwards burned. The flame of pure Hydrogen is pale blue, and emits very little light; but if we throw into it, metallic filings, small pieces of Platinum wire, powdered Charcoal, or any other solid combustible matter, its light becomes increased by the ignition of these substances. In the flames of Candles, Lamps, and Carburetted Hydrogen Gas, the inflammable element is pure Hydrogen; the whiteness and intensity of the light being produced by a quantity of ignited carbonaceous matter, given off by the decomposition of the inflammable matter. The form of flame is conical, because the greatest heat is in the centre of the inflammable mixture. In looking stedfastly at flame, the part where the combustible matter is volatilized is seen; and it appears dark, contrasted with the part in which it begins to burn; that is, where it is so mixed with air as to become explosive. When the wick becomes clogged with Charcoal, it cools the flame, and prevents a proper quantity of air from mixing with its central part; hence the Charcoal thrown off from the top of the flame is only red hot, and much escapes unconsumed.

That flame may be extinguished simply by cooling, Sir H. Davy ingeniously shews, by putting a coil of cold

Platinum wire close to the small flame of a spirit-lamp. It goes out in consequence of the heat carried off by the wire; which will not be the case if the wire be previously heated: or to descend to a more common illustration, when we blow out a candle, the extinction of the flame is produced by the cooling power of the current of air projected into the flame, and the hottest flames are least easily blown out.

Air may be made hot enough to impart a white heat to solid bodies, and yet not become luminous itself; as may be easily shewn, by holding a piece of thin platinum wire over the chimney of an Argand lamp, fed with spirit of wine; or even by the common expedient of lighting a piece of paper, by exposing it to a current of hot air which rushes out of a common lamp-glass. Such being the nature of flame, it is further obvious, that, if we cool it, by any means, we must at the same time extinguish it; and this is accordingly done, by passing it through the metallic apertures of fine wire-gauze, (as in the case of Sir Humphrey Davy's Mine Safety-Lamp,) or any other substance which has considerable conducting and radiating powers in regard to heat, or which, in other words, is capable of producing a cooling effect. Thus a piece of wire-gauze, placed in the centre of the flame of a candle, cuts it, as it were, in half,—the upper part being extinguished by the cooling power of the gauze, while the lower part remains luminous, because it is of a temperature sufficiently high.

The following experiments illustrate the various phenomena of Combustion in *Atmospheric air*, also the relative Combustion of different substances. We deem this order necessary, as it is requisite for the student to be acquainted with the common cases of Combustion, previous to a knowledge of the same, where the Supporters are in a state of purity; he will thus be more able to appreciate the combustive powers of the pure Supporters.

DXII.

A TAPER BURNS IN A JAR OF ATMOSPHERIC AIR,

Only so long as there is Oxygen present to support Combustion.

Fasten a taper to a flat piece of wood, and set it floating in a shallow dish of water: invert over it a glass jar. The Taper will burn for a little time, as when it was uncovered; but the flame will soon become fainter, and at last will be extinguished.

Observation. A mouse immersed in the jar would instantly die, there being only nitrogen and carbonic acid gases in it; all the oxygen having been consumed by the combustion. Combustion is kept up in the Atmosphere by a continued supply of Oxygen.

DXIII.

COMBUSTIBILITY OF CAMPHOR.

Apply a small piece of Camphor to the flame of a candle; it will inflâme. Place it in this state on water in a basin. Here it will not only float and remain in an inflamed state, but will also appear agitated; and in this state will move to and fro on the surface, at the same time emitting a very fragrant smell.

Observation. If during the agitation of the camphor on the water, a drop of oil of peppermint be let fall from a feather, into the vessel, the camphor will suddenly stop, as if arrested by something peculiarly attractive in the oil.

DXIV.

COMBUSTION OF PHOSPHORUS.

Place a piece of Phosphorus, half the size of a pea, on the side of the fire-grate, or on a warm piece of iron; it will soon take fire, burning with a beautiful light blue flame, and giving out a whitish vapour, which is Phosphoric Acid, or Phosphorus combined with the Oxygen of the Atmosphere.

Put a piece of Phosphorus, of the size of two peas, into a gallipot more than half filled with water; place the gallipot upon the fire, and let it boil. Although Phosphorus is heavier than water, still by the boiling heat, it will be gradually converted into vapour, which on ascending to the surface will take fire, exhibiting very beautiful phenomena.

Observation. These phenomena may be accounted for in another way; that is, that the phosphorus, at an elevated temperature, decomposes the water, and unites with its hydrogen, forming phosphuretted hydrogen gas.

DXV.

BORON BURNS IN THE ATMOSPHERE,

When heated to 600°.

Place a small piece of Boron on a fire-shovel, and give it a heat between five and six hundred degrees. Combustion, with a beautiful red light, accompanied by scintillations, will be the consequence.

Observation. Boracic acid will be formed by the union of this substance with the oxygen of the Atmosphere.

DXVI.

IRON-FILINGS BURN IN THE FLAME OF A CANDLE.

Pour Iron-filings upon the Flame of a Candle, from a sheet of paper, about eight or ten inches above it: as they descend in the Flame, they will enter into a very vivid scintillating Combustion.

Observation. The filings which have undergone this combustion, if examined, will be found to be in an oxidised state.

DXVII.

ARSENIC BURNS IN THE ATMOSPHERE.

Throw two or three pieces of metallic Arsenic into a crucible made red hot in the fire; at the instant of projection, they will inflame with a bluish light, and continue in that state until they are totally oxidised.

Observation. This combustion will be attended by a copious emission of white fumes, which have a garlic odour; and the operator should keep at a distance from the fire-place, as they possess noxious qualities.

DXVIII.

COMBUSTIBILITY OF ZINC.

If Zinc-filings are sprinkled on the flame of a candle, they will immediately burn like so much saw-dust. This Combustion is very beautiful, for each grain in the course of inflammation, scintillates, and assumes a luminous starry form.

Put two or three small pieces of Zinc into a crucible, and give it a red heat in a clear fire. A very lively and beautiful Combustion will now take place, from Combination with the Oxygen of the air; and white fumes will arise from the crucible as it goes on: these fumes are the Oxide of Zinc. It is only at a red heat, that Zinc is able to decompose the air with any degree of energy.

A very pleasing variation will take place, if pieces of Zinc are thrown into a red-hot crucible. The metal will burn with very great brilliancy.

If a bar of Zinc be submitted to a heat of 250°, it will be rendered malleable. In this state it may be beaten into thin leaves, by a flat hammer on an anvil. If one of these leaves be presented to the flame of a candle, it will burn almost like a sheet of paper. White fumes of Oxide of Zinc will be evolved.

Observation. If the different compounds used in making fireworks, contain about one-eighth of zinc-filings, (except where explosions are required,) the brilliancy of their combustion will be much increased. Such fireworks present a continued stream of vivid scintillations.

DXIX.

ANTIMONY ENTERS INTO COMBUSTION AT A *White Heat.*

Melt some Antimony in a crucible, (the melting point is 810°,) and when at a white heat, take hold of the crucible with the fire-tongs, and shake it; a very brilliant Combustion will take place, as the Antimony rapidly absorbs Oxygen from the air.

DXX.

GALLIC ACID IS COMBUSTIBLE.

Place a few crystals of Gallic Acid on a red-hot shovel or poker; they will soon enter into combustion, giving out a yellow flame, and a very pleasant odour.

DXXI.

BORACIC ACID IMPARTS A GREEN COLOUR TO THE *Flame of Alcohol.*

Put 1 dram of Boracic Acid into a saucer, and pour over it 4 drams of Alcohol; stir them well together. If this Experiment be performed at night, withdraw the candle from the room, and then set fire to the Alcohol with a lighted piece of paper. The flame will have a very beautiful green appearance, the reflection of which, it will impart to the faces of the spectators.

DXXII.

STRONTIAN GIVES A BRILLIANT RED COLOUR TO THE *Flame of Alcohol.*

Proceed as in the last Experiment; but instead of the former substance, use pulverised Strontian. The flame will be of a very beautiful and brilliant red colour.

Observation. As barytes, or its salts, do not produce this effect; the red flame of strontian distinguishes it from that earth.

DXXIII.

MURIATE OF LIME IMPARTS A RED COLOUR TO THE *Flame of Alcohol.*

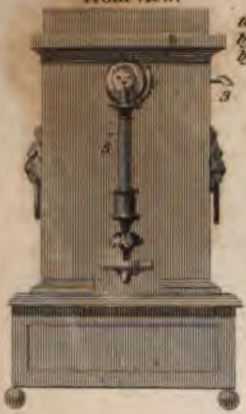
Dissolve 2 drams of dry Muriate of Lime in 4 drams of

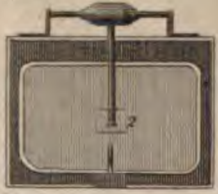
PLATE XI

Volta's Air Lamp,

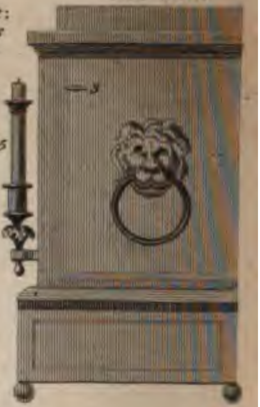
to produce an Instantaneous Light: by firing a stream of Hydrogen Gas by means of the Electrical Spark.

Front View.

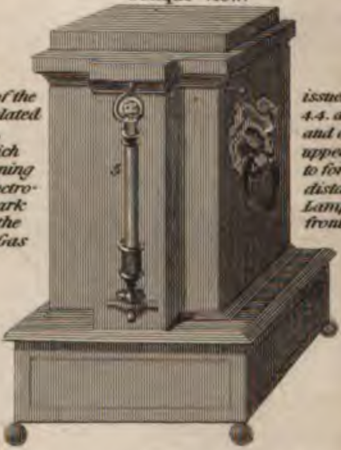




Side View.

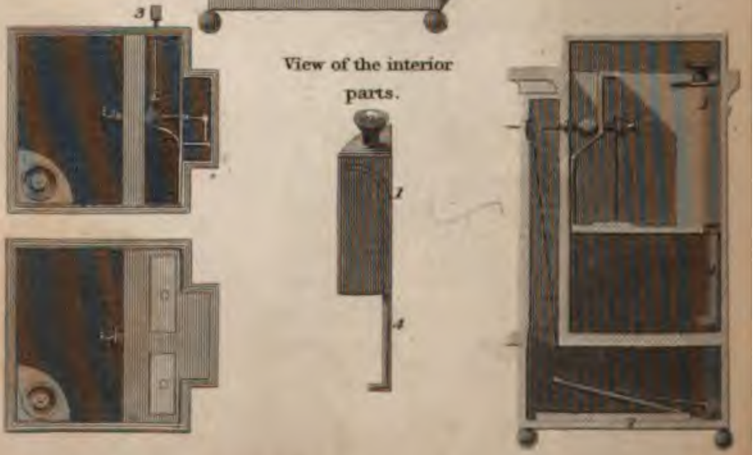


Oblique View.



1. Bottle for the generation of the Hydrogen Gas from Granulated Zinc and Sulphuric Acid.
2.2. is the Electrophorus which produces the spark, by turning
3.3.3. The Winch. When the Electrophorus Plate rises, the spark is taken immediately at the orifice from whence the Gas issues. The Gas passes down
4.4. a pipe into the lower vessel and displaces the water into the upper one, so as to act in a column to force the Gas out at a sufficient distance for firing the Spirit Lamp or taper, 5 placed in the front of the instrument.

View of the interior parts.



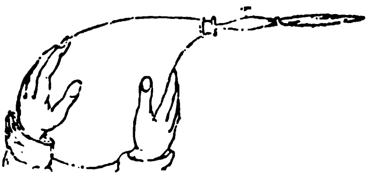
Farey del.

Alcohol; pour the compound into a saucer, and set fire to it by a lighted paper. It will burn with a beautiful carmine flame.

Observations. Plate 18, exhibits an *air-lamp* constructed by M. Volta. In this instrument, hydrogen gas is generated from diluted sulphuric acid and iron or zinc-filings. It is then inflamed by the galvanic action of a double plate (called the electrophorus,) composed of zinc and copper.

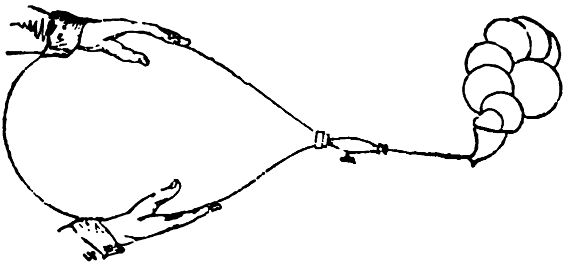
DXXIV.

Combustibility of Hydrogen Gas.



If the flame of a candle be brought into contact with a stream of Hydrogen Gas, rushing out of the stop-cock attached to a bladder, (see the annexed figure,) or jar, charged with it; a beautiful combustion will take place, accompanied by a fine yellowish flame, which may be lengthened to six or eight inches, by pressing the Gas out of the bladder, or by pressing the jar downwards, in the Water of the pneumatic trough.

Fill a bladder (having a stop-cock and brass tobacco-pipe attached, as in the following figure,) with Hydrogen Gas; and having prepared a lather of yellow soap, immerse the bowl of the pipe in it. Now press the bladder so as to form a globe, or bubble, and, as it ascends, inflame it by a candle. The bubble will burst with a vivid flash: the whole of the Gas may be thus expended in successive bubbles and flashes.



DXXV.

The sudden combustion of Hydrogen Gas is *Attended by Explosion.*

Fill a small but strong wide-mouthed phial, with Hydrogen Gas; wrap a pocket-handkerchief round it, to prevent accident, and bring the mouth of it in contact with the flame of a candle, or near a red-hot iron. It will inflame with an obtuse kind of explosion, and will continue burning as long as any Hydrogen remains.

DXXVI.

HYDROGEN GAS EXPLODES, WHEN MIXED WITH *Atmospheric Air, and then inflamed.*

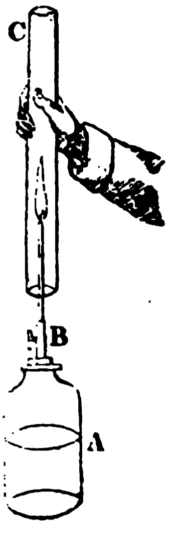
By means of a bellows, half-fill a bladder, having a stop-cock, with common air; and fill the other half with Hydrogen Gas: now screw a brass tobacco-pipe to the stop-cock, and dip it in a basin of soap-lather. When the bladder is pressed, the combined Gases will rush out and form a bubble, which being lighter than common air will ascend. Apply the flame of a candle to each bubble; they will explode with great violence.

Observation. In this experiment, the bubbles should be completely detached from the bowl of the tobacco-pipe, before they are inflamed, or else the flame may rush into the pipe, and communicating with the mixture of gases in the bladder, will burst it.

DXXVII.

MUSICAL SOUNDS PRODUCED BY THE COMBUSTION OF *Hydrogen Gas.*

Prepare a large phial with materials to produce Hydrogen Gas, and having a small tube with a stop-cock fixed in it for the passage of the Gas. Procure an earthen or iron tube two feet and a half long, and from one to two inches wide. As the Gas rushes out, set fire to it, and bring the large tube two or three inches over the small one. In a few seconds, as the flame continues to rush up, very strange but pleasing sounds will be produced, which may be varied by raising or depressing the large tube. The annexed figure will illustrate this experiment. A. Is the phial used in the production of the Hydrogen Gas; B, the narrow tube fixed in the cork; and C, the large tube for the production of the sound.



Observation. This effect of producing sound is owing to the rapid mechanical action of the gas in a state of combustion; for the new-formed product, (the steam produced by union of the hydrogen gas and the oxygen of the atmosphere,) being held in a state of vapour, until the cool sides of the tube and the surrounding atmosphere deprive it of its caloric, fills up a certain space; but when this space is evacuated by departure of the caloric and the consequent condensation of the liquid, an equal portion or bulk of common air rushes in to supply its place. Thus, by a rapid condensation, and succession of currents of air, vibration is caused in the tube; and this vibration produces the sound.

DXXVIII.

SULPHURETTED HYDROGEN BURNS IN THE ATMOSPHERE.

Fill a bladder, having a stop-cock, with this Gas: When it is to be inflamed, open the cock, and light the Gas as it issues forth. It will burn with a flame, varying in colour from bright yellow to blue, reddish and violet.

Observations. Phosphuretted hydrogen gas emits a yellow flame when in a state of combustion. It is that which beguiles the benighted traveller from the road, into bogs and marshes. This moving light has received the appellation of *Jack o'lantern.*

DXXIX.

COMBUSTIBILITY OF HYDRO-ZINCIC GAS.

Put half an ounce of Zinc-filings into a common phial which has a cork perforated to receive a glass tube, or stem of a tobacco-pipe. Pour over the filings half an ounce of Sulphuric Acid, with an ounce and a half of Water. Fit in the cork, and apply a lighted candle to the Gas which rushes out: it will immediately inflame, and continue to burn with a blue light as long as the Zinc is acted on.

Observation. Here, the water being decomposed by the action of the acid and metal, the hydrogen is thrown off; but in combining with small particles of zinc it is transformed into hydro-zincic gas.

DXXX.

A CANDLE ENTERS INTO, AND CONTINUES IN,

A state of Combustion, by being converted into Carburetted Hydrogen Gas.

When a Candle is burnt so low as to leave a tolerably large wick, blow it out; a dense smoke, which is a compound of Hydrogen and Carbon, will arise. If another Candle, or lighted Taper, be applied to the utmost verge of this smoke, a very strange phenomenon will take place: the flame of the lighted Candle will be carried to the one just blown out, as if it were borne on a cloud; or, more properly speaking, like a flash of lightning, proceeding at a slow rate.

Observations. This passage of a body of flame from a lighted candle to the smoking wick, is owing to the combustibility of the materials of which the wick is composed; for the hydrogen and carbon instead of transmitting flame, are themselves made the medium of combustion. It should be remarked, that this passage of flame is accompanied by a slight explosion as it surrounds the wick. This experiment may be performed, by blowing out the candle as often as it is lighted.

SPONTANEOUS COMBUSTION.

The following Cases of Spontaneous Combustion, no doubt, depend much upon the Agency of Carburetted Hydrogen Gas.

Many vegetable substances, highly dried and heaped together, will heat, scorch, and at last burst into flame. Of these, the most remarkable is a mixture of the expressed oil of the farinaceous seeds, as rape or linseed oil, with almost any dry vegetable fibre, such as hemp, cotton, matting, &c. and still more so, if also united with lamp-black, or any other carbonaceous substance. These mixtures if kept for a time undisturbed, in close bundles, and in a warm temperature, even in small quantities, will often heat, and burn with a smothered fire for some hours; and if air be admitted freely, will then burst into flame. To this, without doubt, may be attributed several accidental conflagrations in storehouses, and places where quantities of these substances are kept. Indeed this has been proved by many experiments. The most important of these were made by Mr. George, and a committee of the Royal Academy at Petersburgh, in the year 1781, in consequence of the destruction, by fire, of a frigate in the harbour of Cronstadt; the conflagration of a large hemp magazine, in the same place in the same year; and a slight fire on board another frigate, in the same port, in the following year.

These accidents led to a very strict examination of the subject, by the Russian government; when it came out, that at the time of the second accident, several parcels of matting, tied with pack-thread, in which the soot of burnt fir-wood had been mixed with oil, for painting the ship, had been lying some time on the floor of the cabin, whence the fire broke out. In consequence of this important discovery, forty pounds of fir-wood soot were well soaked in about thirty-five pounds of hemp oil varnish, and the whole was wrapped up in a mat, and put in a close cabin. In about sixteen hours, it was observed to give out a smoke, which rapidly increased, and when the door was opened, and the air freely admitted, the whole burst into a flame. Three pounds of fir-black were mixed with five pounds of hemp-oil varnish, and the whole bound up in linen, and shut up in a chest. In sixteen hours, it emitted a very nauseous putrid smell and steam; and two hours afterwards, it was actually on fire, and burnt to ashes.

In another experiment, the same occurrences took place, but not till the end of forty-one hours after the mixture had been made; and in these and many similar experiments, they all succeeded better, and kindled sooner, in dry, than in rainy weather. Chimney soot used instead of lamp-black did not answer, nor was any effect produced, when oil of turpentine was substituted for the hemp or rape-oil. In general, it was found, that the combination took place more readily with the coarser and more unctuous fir-black, than with the finer sorts; but the proportions of the black to the oil did not appear to be of any great moment. Sometimes, in wet weather, these mixtures only became hot for some hours, and then cooled again, without actually taking fire

In all these cases, the soot or black, was from wood, and not coal. The presence of lamp-black, or any other dry carbonaceous matter, is not necessary however; for, spontaneous inflammation will take place in hemp or cotton, simply soaked in any of these expressed oils, when in considerable quantity, or under circumstances favourable to this process; as in hot weather, or when closely shut up. An accident of this sort happened at Gainsborough, in Lincolnshire, in July, 1794, with a bale of yarn of 120lb., accidentally soaked in rape oil; which, after remaining in a warehouse for several days, began to smoke, to emit a most nauseous smell, and finally to burst out into a most violent flame. A similar accident, with a small quantity of the same materials, happened at Bombay. A bottle of linseed oil had been left standing on a chest; this had been thrown down by accident in the night, the oil ran into a chest which contained some coarse cotton cloth. and in the morning the cloth was found scorching hot, and reduced nearly to tinder, the wood of the chest also was charred on the inside. On subsequent trial, a piece of the same cloth was soaked in oil, shut up in a box, and in no longer time than three hours, it was found scorching hot; and on opening the cloth it burst into flame.

Similar to this, is the spontaneous combustion of wool, or woollen yarn, which has occasionally happened when large quantities have been kept heaped up in rooms little aired, and in hot weather. The oil with which wool is dressed, which is generally rape-oil, appears the chief agent in this combustion. Even high dried, oily, or farinaceous matter of any kind, will alone take fire, when placed in circumstances very favourable to this process. Rye flour roasted till half parched, and of the colour of coffee, and wrapped up in a linen cloth, has been found to heat violently, and to destroy the cloth. Wheat flour, when heated in large quantities, and highly dried, has been known to take fire in hot weather, causing accidents in granaries and bakers' shops. An accident of this kind is related by Count Morrozzo, in the Memoirs of the Turin Academy, to have happened at a flour warehouse at Turin, containing about three hundred sacks of flour. It began by a violent explosion, on a lamp being brought into the warehouse, and the whole was soon after in flames. Charcoal alone also has been known to take fire in powder mills, when quantities of it in powder have been kept for some time closely packed.

Another, and totally different species of spontaneous combustion, is that which occurs during the oxygenation or vitriolization of pyrites, or sulphurets of iron, copper, &c.

A most curious, and, if not well authenticated, a scarcely credible species of spontaneous inflammation, is that in a few rare instances, known to occur in the human body. It is not quite certain indeed, whether the first inflammation has been quite spontaneous, or caused by the approach of a lighted substance; but in these melancholy accidents, the body of the unfortunate sufferer has been brought to a state of such high combustibility, that the flame once kindled, has gone on without other fuel, to the entire destruction of every part, (the bones and extremities excepted) and as it appears, has been attended with actual flame, of a lambent faint light. This change is the more remarkable, as the human body, in all its usual states, both of health and disease, is scarcely at all of itself combustible, and cannot be reduced to ashes without the assistance of a very large pile of faggots, or other fuel; as universal experience, in the very ancient mode of sepulture, and the history of martyrdoms, abundantly shews. Cases of this human combustion on record, have occurred in different countries. Two of them, well authenticated, are recorded in the Philosophical Transactions, and occurred in England; and a few others in Italy, France, and elsewhere. In all but one, the subjects of them have been females rather advanced in life, of indolent habits, and apparently much addicted to spirituous liquors.

The accident has generally been detected by the penetrating fetid smell of burning and sooty films, which have spread to a great distance; and the sufferers have in every instance been discovered dead, and with the body more or less completely burnt up, leaving in the burnt parts only an oily, crumbly, sooty, and extremely fetid matter. Another circumstance in which these cases all agree, is the comparative weakness of the heat produced by this combustion, notwithstanding the very complete disorganization of the body itself, so that the furniture of the room, wooden chairs, &c. found within the reach of the burning body, were in many instances absolutely unhurt, and in others only scorched; the heat not having been strong enough to set them on fire. It is impossible to give an adequate reason for this remarkable change; nor does it seem before the very time of the accident to have produced any very sensible alteration in the appearance and functions of the body, which is certainly a most astonishing circumstance. With regard to the effect which the use of ardent spirits is supposed to have in this case, it is impossible not to imagine that this cause may contribute largely to such a change; but the instances of the abuse of spirits are so innumerable, and those of this surprising combustion are so extremely rare, that very little satisfaction can be obtained from this explanation.

Hydrogen gas enters largely into all animal, vegetable, and many mineral compositions. Hence, it is frequently set at liberty by fermentation or spontaneous decomposition in bogs and marshes; when from electricity or some other accidental cause, it is often set on fire. This phenomenon has been observed in almost all parts of the world. In Persia it is converted into a *pious fraud* by the priesthood, who by means of hollowed reeds, convey the carburetted hydrogen gas into one of their temples, which has been purposely built upon ground abounding in bitumen, naphtha, and other inflammable substances. As the Persians have always been worshippers of fire, the imposition is a happy one, for in this temple, they are continually feasted with a view of their Deity.

At Moulton, near Northampton, in the forenoon of September, 11th, 1810, a fire broke out in an ash-spinney. Mr. Marsh, the proprietor immediately went to the spot with some friends, and found the *fire issuing from the earth* in many places, and in a short time it would have communicated to a gorse cover, had it not been for the timely assistance of several persons whom curiosity had brought to witness this extraordinary phenomenon. As there was some lightning during the morning, it was imagined a fire-ball had been the cause, but it was generally supposed to be occasioned by the excessive dryness of the ground, which had been a bog, recently drained for planting; and that the extreme heat of the sun had caused it to ignite.

DXXXI.

CARBURETTED HYDROGEN GAS ENTERS INTO COMBUSTION.

In the Atmosphere.

Fill the bowl of a tobacco-pipe with some pulverised rich

Coal; and having covered it over with moistened Clay, to prevent escape of the Gas, place it in a clear fire: in a few minutes, a dense smoke will issue from the stem, which, on the application of a candle, will inflame, and continue in a state of beautiful Combustion as long as the Gas continues to be distilled. The Coal in the bowl will now be found to be converted into a slag or cinder.

Observations. This experiment represents on a small scale, the manufacture of carburetted hydrogen gas for the supply of streets, houses, &c.

ILLUMINATION OF STREETS, &C. BY CARBURETTED HYDROGEN GAS.

"*When pit-coal is burnt in an open fire-place, it emits flame, which is occasionally exhibited in streams of peculiar brightness. This flame is coal gas in a state of combustion. But, besides this gas, there are expelled from the coal, by the action of heat, an aqueous ammoniacal vapour, (which, on being condensed, forms liquid Ammonia,) a thick fluid, nearly resembling tar, and some non-inflammable gases. The wavering and changing of the colour of flame proceeding from a coal-fire, is occasioned by the variety of products which coal affords; and, as these are evolved, we have at one time, streams of brilliant light, at another, clouds of dense and aqueous vapour, thrown off as smoke. Thus by coals being burnt in the ordinary way, we have evident proofs that they contain an inflammable gas, (which, if collected and properly applied, would serve as a substitute for the light obtained by using candles or oil,) together with other valuable products; we must therefore be aware, that should they be distilled in close vessels, the various parts of which they are formed, may be collected. Such part of the coal as is bituminous, will melt out, and be exhibited in the form of Tar. That which contains ammoniacal salts, will be thrown off as vapour; and, on condensation, will appear as an amber-coloured fluid, more or less charged with ammonia, according to the quantity of the coal, and the circumstances under which the distillation may have been carried on. Whilst the above products are evolved, a considerable quantity of carburetted hydrogen gas, and some uninflammable gases, are also generated. These, having all been freed from the coal by the action of heat, and collected, in their respective reservoirs; its base, which is a carbonaceous substance, known by the name of coke, remains in the retort. The coal-gas, being freed from the sulphuretted hydrogen and non-inflammable gases, is fit for use, and may be forced out of the gas-holder, where it is collected, to any distance, by means of cast-iron pipes, laid under ground; from whence, smaller pipes, of wrought-iron and copper, convey it to the respective houses where it is to be burnt. At the extremity of the pipes are fixed burners, to which, by means of stop-cocks, the gas is admitted; and, through orifices made in the burners, it escapes, and is ignited for the purpose of affording light. Thus, from pit-coal, (an article existing in considerable quantities in this country,) may be obtained light of a superior quality to that afforded by the use of wax, tallow, or oil; and at a considerably less expence.

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* Peckston on Gas-lights.

"If we compare the theory of the production of gas-light with that of the production of artificial light by means of candles or of lamps, we shall instantly perceive that the principles are similar, for, in candles or lamps, the wick bears a like situation to that of coal, when submitted to distillation in a close vessel. The wick of a candle serves to convey the melted tallow, by capillary attraction, to where it is consumed. It is there decomposed, and forms carburetted hydrogen gas; as this is made use of, a fresh supply is constantly kept up, which maintains the flame. The burning of oil in a lamp depends on similar circumstances; for, the tubes formed by the wick transmit the inflammable gas through them, in the same way that the heated retort generates coal-gas.

"When coal-gas is used as a substitute for light afforded by the combustion of tallow or of oil, the distillatory process for lighting streets, nay, whole towns and large cities, is carried on in one place, perhaps far from where the light may be wanted; whilst, by the action of candles or lamps, the process is performed wherever such candle or lamp is to be used, *viz.* at their respective wicks.

"The flame of coal-gas, when properly managed, (by allowing no more gas to pass the burner than will be entirely consumed,) produces no smoke; and it is not, like the flame of candles and lamps, subject to emit sparks,—therefore not so dangerous; nor is it so liable to be put out by sudden gusts of wind, or by heavy rain."

Mr. Ackerman, print-seller in the Strand, for several years has lighted the whole of his establishment, together with his dwelling-house, entirely with gas, for about forty pounds per annum, by means of a small apparatus erected on his premises; and he states the annual expence of lighting the same, prior to using the gas-lights, to have been one hundred and sixty pounds; so that it appears, the balance in favour of using the gas-lights was one hundred and nineteen pounds fifteen shillings, for one year.

Mr. Cook, manufacturer of metal toys, at Birmingham, has stated, that for four pence a-day, he generated as much gas as afforded light equivalent to what was obtained by burning as many candles as cost him three shillings; besides a saving of thirty pounds per annum in candles, oil, and cotton, for soldering, which, since the adoption of gas in his premises, has been performed solely by gas-flame. In short, that he saves annually thirty pounds out of the fifty pounds which his lights formerly cost him.

As to the use of gas-light in shops, counting-houses, and public offices, it must be allowed a superiority over candles or lamps. It yields a pure white light, nearly equal to day-light, and at the same time produces such a degree of warmth, as almost to render fire, in the place where it is burnt, unnecessary. A gas-light flame may be so enlarged as to heat apartments of the largest dimensions.

Gas-lights cannot be used with economy on a small scale; such, for instance, where only three or four lights are wanted. Coal-gas is most advantageously manufactured, when streets and houses are to be lighted: were the street-lamps, only, supplied by coal-gas, its production could not be attended with profit. Therefore, to make it answer the manufacturer's views, he ought also to light shops, and the interior of private houses, from the same range of main-pipe as supplies the street-lights.

The price of coals can make but little difference in the price of gas; for, where coals are plentiful, it follows that they will be cheap; so will also the coke; but where coals are dear, the coke will also fetch a high price, and find a more ready market.

DESCRIPTION OF THE PORTABLE GAS-LAMP.

Mr. Gordon, of Edinburgh, has invented a lamp, where carburetted hydrogen gas may be condensed, and used as a moveable light. Its application to the lighting of private and public carriages, as well as to coal-mines, (under the safeguard of Sir H. Davy's invention,) will doubtless be speedily put in practice; and we hope the time is not distant, when reservoirs of condensed gas shall be established in every town and village of Great Britain, and when the lonely cottages of the poor shall be enlivened by this economical and cheerful light. There is one application of the portable gas-lamp to which we attach a very high value. By an extreme diminution of the aperture, the flame can be rendered so small (in which case it is reduced to a blue colour) as to give no perceptible light, and to occasion almost no consumption of gas. In this state, the lamp may be used in bed-rooms; and the imperceptible flame may at any time be expanded into the most brilliant light, by turning the cock, by means of a metallic rod terminating near the bed. The annexed figure represents one of the portable gas-lamps, six inches in diameter, and nine inches high, exclusive of the hemispherical ends and burner at the top; which, when filled with coal-gas, condensed twenty-five times, will supply a lamp equal to five candles, six to the pound, for six hours; and when filled with vegetable oil-gas, will burn for about twelve hours. A similar cylinder, six inches in diameter, and two feet high, exclusive of the hemispherical ends, is calculated to supply an Argand burner, equal to ten candles, for six hours with coal-gas and for twelve hours with vegetable oil-gas.

Gas lights require no trimming, snuffing, nor any trouble whatever, except merely turning a cock, by which a flame of any size may be formed. This is of the greatest advantage in theatres, churches, and public assemblies, especially as it may be so purified that no smell is perceptible from the burning of the gas.

CARBURETTED HYDROGEN GAS IDENTICAL WITH THE FIRE-DAMP OF COAL MINES.

Great care is requisite to keep coal works continually ventilated by perpetual currents of fresh air, to expel the damps and other noxious exhalations. In the deserted works, large quantities of these damps are frequently collected, and often remain for a long time without doing any mischief; but when, by some accident, they are set on fire, they produce dreadful and destructive explosions, and burst out from the pits with great impetuosity, like the fiery eruptions from burning mountains. The coal in these mines has several times been set on fire by the fire-damp, and has continued burning many months, until large streams of water were conducted into the mines. Several collieries have been entirely destroyed by such fires; and in some the fire has continued burning for ages.

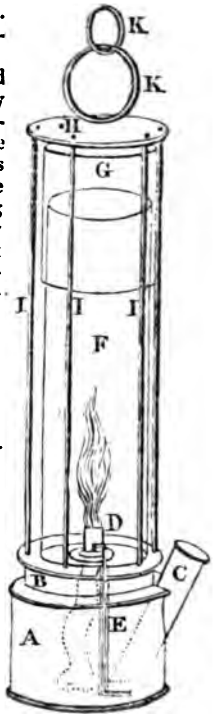
The late Mr. Spedding, having observed that the fulminating damp could only be kindled by flame, *and was not liable to be set on fire by red hot iron, nor by the sparks produced by the collision of flint and steel*, invented a machine, in which, whilst a steel wheel was turned round with a very rapid motion, flints were applied to it; and by the abundance of fiery sparks emitted, the miners were enabled to carry on their work in places, where the flame of a lamp or candle would occasion dreadful explosions

But it was reserved for Sir H. Davy to put an entire stop to these destructive ravages of the fire-damp.

The carburetted hydrogen gas, is that which is so destructive by explosion. By the miners it is called *Fire-damp*, to distinguish it from Carbonic Acid Gas, which they call *Choke-damp*. It is disengaged during the working of the coals, from fissures in the strata; and when it has accumulated, so as to form more than one thirteenth part of the volume of the atmospheric air, it becomes explosive by a lighted candle, or by any kind of flame.

DESCRIPTION OF THE SAFETY-LAMP.

To obviate the destructive effects of this Gas, Sir Humphrey Davy turned his attention to the construction of a lamp which would prevent explosion; and upon the knowledge of the fact, *that flame cannot pass through apertures of small diameter*, he constructed what the miners have since, in gratitude, called '*the Davy*.' The apertures in the gauze should not be more than one-twentieth of an inch square. As the fire-damp cannot be inflamed by ignited wire, the thickness of the wire is not of importance; but wire of one-fortieth to one-sixtieth of an inch in diameter is the most convenient. If the wire of one-fortieth be found to wear out too soon, the thickness may be increased to any extent; but the thicker the wire, the more will the light be intercepted; for the size of the apertures must never be more than one-twentieth of an inch square. In the working model which Sir H. Davy sent to the mines, there were 748 apertures in the square inch.



When the wire-gauze Safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms as much as one-twentieth of the volume of air, the cylinder becomes filled with a feeble blue flame; but the flame of the wick appears burning brightly within the blue flame, and the light of the wick continues, until the fire-damp increases to one-sixth or one-fifth, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any explosive mixture of Gas exists in contact with the lamp, so long it will give light, and when it is extinguished, (which happens, when the foul air constitutes as much as one-third of the volume of the atmosphere,) the air is no longer proper for respiration. In cases in which the fire-damp is mixed only in its smallest explosive proportion with air, the use of the Wire-gauze Safe-lamp, which rapidly consumes the inflammable Gas, will soon reduce the quantity below the explosive point; and it can scarcely ever happen, that a lamp will be exposed to an explosive mixture containing the largest proportion of fire-damp: but even in this case, the instrument is absolutely safe; and should the wires becomes red hot, they have no power of communicating explosion. Should it ever be necessary for the miner to work for a great length of time, in an explosive atmosphere, by the wire-gauze safe-lamp, it may be proper to cool the lamp occasionally by throwing water upon the top; or a little cistern for holding water may be attached to the top, the evaporation of which will prevent the heat from becoming excessive.

The foregoing figure represents the Wire-gauze Safe-lamp. A, Is the cistern which contains the oil. B, the rim in which the wire-gauze cover is fastened to the cistern by a moveable screw. C, an aperture for supplying oil, fitted with a screw or a cork. D, the receptacle for the wick. E, a wire for raising, lowering, or trimming it, and which passes through a safe tube. F, the wire-gauze cylinder, which should not have less than 625 apertures to a square inch. G, the second top, three quarters of an inch above the first. H, a copper-plate, which may be in contact with the second top. I, I, I, I, thick wires surrounding the cage to preserve it from being bent. K, K, are rings to hold or hang it by.

Gas, in a state of flame or combustion, will not pass through brass-wire-gauze with pores of certain dimensions, although the gas itself, when not in a state of flame, most readily passes. If a piece of wire-gauze be held horizontally over the flame of a common gas-light, the flame of the gas will burn under the wire-gauze, but it will not pass through it in the state of flame. If again, whilst the wire-gauze is held over the flame, a candle be applied to the upper surface of the gauze, the gas passing through it, will immediately kindle. The theory is this: —gas must be heated to a certain degree, either by the immediate contact of flame or some other body, before it will either burn or explode; the gas, in passing through the wire-gauze, loses so much of its heat,—or, in other words, the wire-gauze conducts away from it so much of its heat,—as to cool it below the degree in which it will burn or explode: hence the important use of the safety lamp, whilst burning in mixtures of atmospheric air and carburetted hydrogen gas. The wire-gauze, with which the lamp is completely surrounded, cools the gas to a degree below the heat necessary for the explosion to take place; and, consequently, no explosion can happen. In no instance has the safety-lamp been known to fail in preventing explosions in coal-mines, whilst the workmen have continued to keep the wire-gauze around it.

Respecting several trials which Sir H. Davy made with these lamps, he gives the following account, in a letter, from Newcastle-upon-Tyne.

"The inspection of a number of wire-gauze safe-lamps, that have been long in common use in the coal-mines; and the examination of the effects of different explosive atmospheres of fire-damp upon them, enable me to offer a few suggestions, which I hope will be of use to the miner.

"The wire-gauze cylinders ought never to be taken out of the screw-piece in which they are fixed; and, in the lamps constructed at Newcastle, which have not the same rim of wire-gauze as those of Newman's construction, the wire-gauze ought to be soldered to the screw-piece, or fixed to it by rivets.

"The wire-gauze is easily cleaned without being detached, by a brush of the same kind as that used for cleaning bottles, and one of these brushes ought to be furnished with every lamp.

"The wire-gauze in several lamps in the collieries, which had been in use six months, and cleaned by careful workmen, without being removed, was as good as new; whereas, the gauze in some, that had been used for a much shorter time, and taken out of the lamp and cleaned roughly, was injured at the bottom, and if not actually unsafe, was becoming so.

"In one instance, I found a lamp which had been furnished to a workman without a second top. This is a gross and unpardonable instance of carelessness in the maker, who, if any accident had happened, would have been guilty of homicide.

"All the Lamps that I have examined, have, at different times, been red hot; and a workman at the Hepburn colliery shewed me a lamp which, though it had been in use about sixteen hours a-day, for nearly three months, was still in excellent condition; he also said, it had been red hot, sometimes, for several hours together. Wherever workmen, however, are exposed to such highly explosive mixtures, double gauze-lamps should be used; or a lamp in which the circulation of the air is diminished by a tin-plate reflector placed in the inside, or a cylinder of glass reaching as high as the double wire, with an aperture in the inside; or slips of Muscovy glass may be placed within the lamp, and in this way the quantity of fire-damp consumed, and consequently of heat produced, may be diminished to any extent. Such lamps, likewise, may be more easily cleaned, than the simple wire-gauze lamps; for the smoke may be wiped off in an instant, from the tin-plate or glass.

"If a blower, or strong current of fire-damp is to be approached, double gauze-lamps, or lamps in which the circulation of air is interrupted by slips of metal or glass, should be used; or if the single lamp be employed, it should be put into a common horn or glass lanthorn, the door of which may be removed or open.

"The wire-gauze is impermeable to the flame of all currents of fire-damp, as long as it is not heated above redness; but, if the iron wire be made to burn, as at a strong welding heat, of course it can be no longer safe; and though such a circumstance can, perhaps, never happen in a colliery, yet it ought to be known and guarded against. And if a workman, having a single lamp, should accidentally meet a blower acting on a current of fresh air, he ought, on finding his lamp becoming hot, to take it out of the point of mixture, or screen it from the current.

"I have had an excellent opportunity of making experiments on a most violent blower, at a mine belonging to J. G. Lambton, esq. some of them in the presence of Mr. Lambton; in most of them Mr. Buddle assisted. This blower is walled off from the mine, and carried to the surface, where it is discharged with great force. It is made to pass through a leathern pipe, so as to give a stream, of which the force was felt at about two feet from the aperture in a strong current of air. The common single working lamps and double gauze lamps were brought into this current, both in the free atmosphere and in a confined air. The gas burned in the lamps in various trials, but did not heat them above dull redness, and when they were brought far into the stream they were easily extinguished.

"A brass pipe was now fixed upon the blower tube, so as to make the whole stream pass through an aperture of less than half an inch in diameter, which of course formed a most powerful blow-pipe, from which the fire-damp, when inflamed, issued with great violence, and a roaring noise, making an intense flame of the length of five feet. The blow-pipe was exposed at right angles to a strong wind, and the double gauze lamps and single lamps successively placed in it. The double gauze lamps soon became red-hot at the point of action of the two currents, but the wire did not burn, nor did it communicate explosion. The single gauze lamp did not communicate explosion, as long as it was red hot, and slowly moved through the currents; but, when it was fixed at the point of most intense combustion, and reached a welding heat, the iron wire began to burn with sparks, and the explosion then passed.

"In a second and third set of experiments on this violent blow-pipe of fire-damp, single lamps, with slips of tin-plate on the outside, or in the inside, to prevent the free passage of the current; and double lamps, were exposed to all the circumstances of the blast, both in the open air and in an engine-house, where the atmosphere was explosive to a great extent round the pipe, and through which there was a strong current of atmospheric air; but the heat of the wire never approached near the point at which iron wire burns, and the explosion could never be communicated. The flame of the fire-damp flickered and roared in the lamps, but did not escape from its prison.

"There is no reason ever to expect a blow-pipe of this kind in a mine; but, if it should occur, the mode of facing it and examining it, with most perfect security, is shewn: and the lamp offers a resource, which can never exist in a steel-mill, the sparks of which, would undoubtedly inflame a current of this kind.

"Arguments have been stated as to the weakness of the lamps. In a board or gallery in the Wallsend colliery, Mr. Buddle and myself, with some of the viewers, endeavoured to injure a single gauze lamp by throwing large pieces of coal upon it, and striking it with a pick; but we never perforated the gauze, and the lamp, after these severe trials, burnt with perfect security in a small explosive atmosphere, made by Mr. Buddle at the bottom of the shaft for the purpose of trying the lamps.

"I made, with Mr. Buddle and his viewers, some experiments on the comparative light of the lamps, the common miner's candle, and the steel mills, in a gallery in the Wallsend colliery. We judged of the intensity of the light by the square of the distance at which a small object was visible; and made repeated trials on each species of light.

The light of the miner's candle was	45.5
That of a lamp furnished with a tin plate reflector for diminishing the circulation of the air, and facing a blower, was . .	49.
That of a single common lamp	39.
That of a double copper wire lamp	25.
That of the steel mill, very unequal and uncertain, but, at its greatest intensity of light	25.

"It may be proper to observe, without reference to the superiority of light, that coals may be worked nearly twice as cheap by the wire-gauze safety-lamp as by the steel mill.

"The pleasure of seeing the wire-gauze safe-lamps in general use amongst the miners, and of adding to the security and happiness of this useful class of men, amply repays me for the labour of twelve months, devoted to their cause, and for the anxiety which I have often experienced during this progress of the investigation.

"*Newcastle; Sept.* 9, 1816. H. DAVY.

P. S. I have shewn in the Transactions of the Royal Society, that the power of heated wire gauze to permit the passage of the flame of coal-gas, is directly as the size of the apertures, and to a certain extent, as the velocity of the current; I say, to a certain extent, because, by a current of a certain velocity, flame is extinguished. A very slight motion will pass the flame of coal-gas through wire-gauze, having less than 400 apertures to the square inch, even when it is heated to dull redness; but a very strong current, and an ignition above redness, visible in day-light, is required to pass the same flame through wire-gauze having above 700 apertures to the square inch; and I have never been able to pass the flame of coal-gas, or any carbonaceous flame, through wire-gauze having more than 1600 apertures to the square inch, by any means.

"The experiments above detailed on the blower are the first I have made upon *currents of fire damp*. They prove what I had inferred from its other properties, and they offer simple means of rendering wire-gauze lamps perfectly safe against all circumstances, however extraordinary and unexpected, and of placing their security above the possibility of *doubt or cavil*."

An improvement of great importance has lately been made to this lamp, by which its utility will be increased. It consists in attaching to the lower part of the wire gauze a convex lens; the effect of this is, that the miner will have it in his power to direct a strong light upon any particular part where it may be required, while the lens has the further advantage of covering a portion of the gauge, and preserving it from the coal-dust and oil, by which, without considerable care, it is liable to be obstructed.

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By the foregoing Experiments it has been proved, that atmospheric air owes its capability of supporting combustion, to the existence of Oxygen in its composition. The following show that there are many Gases which cannot support combustion.

DXXXII.

NITROGEN GAS.

If a lighted candle be immersed in a jar of Nitrogen Gas, it will be immediately extinguished. This proves that this Gas cannot support Combustion.

DXXXIII.

HYDROGEN GAS.

Lift a Bell-glass filled with Hydrogen Gas, suddenly from the Pneumatic shelf, and place it over a lighted candle; the flame will be instantly extinguished: thus, although Hydrogen Gas is itself a combustible substance; still, it cannot support Combustion.

Observation. Hydrogen gas (prepared by the action of zinc on water with muriatic acid,) when condensed alone in the reservoir of the gas blow-pipe, and ignited, has been found to have heat enough for the fusion of platinum foil, and the combustion of iron wires.

DXXXIV.

Muriatic Acid Gas.

Immerse a lighted taper in a jar of Muriatic Gas;—the flame will become dim, and assume a greenish colour, at the upper part. It will then be extinguished, and will immediately after give out white fumes.

DXXXV.

Sulphurous Acid Gas.

Immerse a piece of burning Phosphorus (contained in a Platinum Spoon) in a jar of Sulphurous Acid Gas. Although previously undergoing violent combustion, the instant it comes in contact with this Gas, it will be extinguished.

DXXXVI.

Carbonic Acid Gas.

Immerse a kindled Sulphur match in a jar of Carbonic Acid Gas;—the instant the flame comes in contact with the Gas, it will be extinguished.

As Carbonic Acid Gas is specifically heavier than Atmospheric Air, this Experiment may be varied, by placing a lighted taper at the bottom of a jar, and by pouring upon it, from another, a stream of Carbonic Acid Gas. This is done by taking the Carbonic acid jar from the Pneumatic shelf, and quickly inverting it over the jar containing the taper. The effect will be very striking, for the Gas being invisible, like most other Gases, will descend in a stream and extinguish the flame: but the whole will appear an illusion to those spectators, who have no idea of substance without sensible matter.

Observations. It is this gas which is generated in old mines, wells, caverns and cellars; and which is so pernicious to animal life. Before an old well is entered, to open it afresh, it is customary first to send down a lighted candle by a rope or line. If the flame be extinguished before, or when it reaches the bottom, it is always unsafe to descend. On such an occasion, it will be proper to throw down about half a bushel of fresh burnt lime; and to try the effect of the air in the pit upon a lighted candle, in about a-week after.

Whilst treating of the want of power of these gases to support combustion, it may not be amiss to notice the attempts made to prepare an *Antiphlogistic fluid,* whereby fires may be extinguished and heat resisted.

It is recorded in the French Archives of Science, that several experiments were made at Venice in 1807, by a Monsieur Gazzetti, with a liquor, which being thrown in a small quantity on any combustible article on fire, has immediately extinguished it. A few drops, only, being thrown on a quantity of rosin and oil, which was burning, the fire was immediately extinguished; and it was said that a layer of this composition being spread upon any wood work, it was entirely safe from combustion. The Editor of the work alluded to, adds, that the inventor would not make known the preparation of his composition, but that it was, very probably, a solution of alum, potass, and vitriol. No doubt this idea of the composition of the Venetian fluid was tolerably correct; for very lately, in England, an *Alkaline mixture* has been found to posess Anti-phlogistic properties.

A committee appointed by the Board of Ordnance, inspected a machine invented by Captain Manby, for the extinction of fire by an anti-phlogistic fluid, at the committee room, Woolwich barracks. He shewed that it could be instantly applied (being kept ready loaded) to fires which were so situated that a common fire engine would be of no service: for instance, in the back apartments of a house, or under the deck of a vessel. He explained the nature of the fluid which the machine was charged with; it consists of lime with potash, and a certain quantity of water, and might be made in two minutes; on ship-board a cask of it might always be in readiness, besides the machine being charged with it. To exhibit the extraordinary effects of the anti-phlogistic ingredients, he immersed in it a quantity of hemp, canvas, and deal wood, which are the most combustible materials used in a dock yard; he also immersed the same materials in common water, and applied a certain heat to each; those which had been dipped in the anti-phlogistic fluid would not burn, and those dipped in common water blazed immediately. He also sprinkled some hemp with the fluid, and some with common water, which had the same effect;—that sprinkled with water burned, and the other did not.

Analagous to this mode of preventing combustion is that used by fire-eaters, and other miracle-mongers of the same description. M. Sementini a chemist of Naples having most ingeniously detected the mode used by a Spanish exhibitor of this sort, has given to the world a very interesting detail of these exploits, with his own discoveries on the subject. We present the reader with this narrative in the Professor's own words, as reported in the Moniteur Universelle for November 6th, 1809.

THE INCOMBUSTIBLE MAN.

"Signior Lionetto commenced his tricks by putting on his head a slender ring or hoop of red-hot iron, and which to all appearance made no impression on his hair; but when the hoop of iron came in contact with the hair, a thick vapour was seen to ascend. He then took another piece of red-hot iron and passed it over the whole length of his arm and his leg, and he applied for a considerable time another piece of hot iron to his heel and his foot, from whence also ascended such a thick and disagreeable vapour, that my eyes and lungs were much affected thereby. He also held between his teeth a piece of iron, which, although not red, was sufficiently hot to burn. He had given out, that he would drink half a glass of boiling oil: but I did not find that he could take any such dose, and I only saw him take within his mouth about the quarter of a spoonful. It was also reported, that he had washed his face and hands in boiling lead; but he contented himself before me, with quickly dipping the ends of his fingers in the melted metal, and putting a small quantity thereof on his tongue,* after which he applied a piece of hot iron to his tongue, seemingly without any inconvenience; while repeating this experiment several times, I clearly perceived his tongue to be covered with the appearance of a grayish skin, similar to that of a person having a fever.

"Another of his experiments was that of thrusting a thick golden pin through the skin of his arm, without feeling the least pain; in this proof of his insensibility, I observed, that the pin went through his skin, with great difficulty, and required as much force as if it had been applied to tanned leather.

"Instead, therefore, of uselessly wasting time in simple conjectures, I resolved to adopt the best experimental arts, trying on myself the action of all the means proper to benumb the cutaneous nerves, and to clothe the skin with a substance which was a non-conductor of caloric. Few substances belonging to chemical compositions, appeared to me proper for this purpose. The sharp sensation which was excited by the vapour, disengaged by the contact of fire with the incombustible membrane, and the chemical reason, induced me first to have recourse to acid substances, and to some of the acidulous salts.

"These essays with the acidulous salts, and alum in particular, were only the rudiments of a knowledge of the phenomenon, the examination of which was still incomplete. An accidental combination afterwards induced me to undertake a new series of experiments, by which I might be enabled to give a more clear explanation of all the more difficult operations executed by this reported Incombustible man. Wishing to examine if washing the almost incombustible part (rendered so by the action of alum), would make it lose the quality it had acquired, I rubbed it with hard soap, then washed and dried it with a cloth, and then applied a piece of red-hot iron. I was then much surprised to find, that the skin of that part not only preserved the same insensibility, but was even stronger than at first. I again rubbed the same part with soap, without wiping it with the cloth, and passed over it the red-hot iron, without feeling the least effect of burning or even of singeing the hair. Remembering the crust which I had observed on the fire-eaters tongue, I was determined to rub mine with the same sort of soap, and it fully answered the desired purpose, beginning first with iron slightly heated, and raising the heat gradually until it was red hot. I made a soft paste of soap, triturated in a mortar, with water saturated by acidulous sulphate of alumine and potass; and spreading this composition on my tongue, the experiment completely succeeded. Still more simple, I found the process of first bathing the tongue with sulphureous acid, and afterwards rubbing it often with a piece of soap. The experiment succeeded still better, when after bathing the tongue with this acid, I covered it with a thin stratum of sugar reduced to impalpable powder, and rubbed it afterwards with the soap in the same manner. The sugar, in this case, like a mordant, made a greater quantity of soap adhere to the tongue. Of all the known substances, soap is that which best merits the name of restrainer of caloric.

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* The probability is, that in this part of the Exhibitions of Fire-eaters, the lead is not in a state of purity; but combined with mercury, and perhaps bismuth. See Experiments on amalgams and fusible alloys in Chapter 1. of this volume. The deception is a probable one, for these alloys can hardly be distinguished from melted lead by their colour.

"From these experiments I proceeded to that with the boiling oil, putting at first a very small drop considerably heated on my tongue, and afterwards increasing the quantity and heat. This experiment was also satisfactory; the oil put on the tongue, thus prepared, made a hissing noise, similar to that made by red-hot iron when brought in contact with a humid body; after the hissing, the oil ceased to be hot, and was easily swallowed. From all these facts, I am led to account as follows for the phenomena exhibited by *Lionetto*.

"1. The hair over which he passed the hot iron, had been first bathed with a solution of alum; and hence, the origin of the vapour which arose from his hair.

"2. The hot iron with which he rubbed his legs and arms produced no bad effects, from a similar preparation being used.

"3. The same reason will also apply to the experiment with his foot, although the contact with the iron was much longer; but it is well known that the foot is the most callous part of the human body.

"4. With respect to the boiling oil, we will minutely follow *Lionetto's* experiments. He took the oil from the fire, and to convince the audience of its high temperature, he threw therein a quantity of lead, which melted; but it is only reasonable to conclude, that this was a mere stratagem to cool the oil. Of the oil thus cooled, he took barely a quarter of a spoonful, and this he let dexterously fall on his tongue only; which was perhaps prepared, in such a manner, that it immediately cooled the oil, which was then swallowed scarcely tepid.

"5. The experiment of the melted lead, in which he occasionally dipped his fingers, and put a very small quantity, not in his mouth, but on his tongue, can easily be accounted for in the same way."*

Very different indeed from the action of the foregoing Gases on combustible bodies, is that of Oxygen Gas. This Gas in an eminent degree supports combustion. In all these cases, the Oxygen combines with the combustible substance, forming either an Acid or an Oxide. The combustion will be at an end when the Oxygen is exhausted.

DXXXVII.

A LIGHTED TAPER WILL BURN VIVIDLY

In Oxygen Gas.

If a lighted taper be introduced into a jar filled with Oxygen Gas, it will burn with wonderful splendour and heat; if it be suddenly withdrawn, and the flame extinguished by the breath, (but the wick still in a kindled state) and again introduced, it will immediately burst into a flame, with a sort of flat or obtuse explosion.

Observation. This may be as frequently performed as the quantity of oxygen gas will permit; and the experiment may be varied by the introduction of ignited slips of wood or paper.

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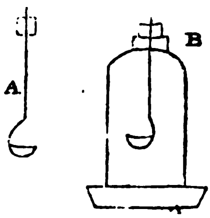
* See Foot-note, Page 303.

DXXXVIII.

IGNITED CHARCOAL BURNS WITH MUCH SPLENDOUR *In Oxygen Gas.*

If a piece of ignited Charcoal be put into a small Platinum spoon, and immersed in a jar of Oxygen Gas; Combustion, with great splendour, will take place, and Carbonic Acid will be formed by the union of the two substances. The annexed cut represents a jar of Oxygen Gas, with the Platinum spoon. A, is the spoon; B, the jar.



DXXXIX.

SULPHUR BURNS BEAUTIFULLY IN OXYGEN GAS.

If a piece of Sulphur in a Platinum spoon, be set on fire, and in that state immersed in a jar of Oxygen Gas, it will burn with a beautiful violet-coloured scintillating flame; at the same time, the jar will be filled with a brown vapour, which is Sulphurous Acid Gas; the same as when Sulphur is burnt in the open air, by combining with its Oxygen.

Observation. This Gas will quickly be absorbed by the water in the saucer, forming sulphurous acid.

DXL.

PHOSPHORUS BURNS WITH ASTONISHING SPLENDOUR *In Oxygen Gas.*

Fill a clear glass bottle with Oxygen Gas, and prepare a wire hooked at one end, the other being fixed in a cork that fits the bottle; upon this hook place a piece of Phosphorus, of the size of a pea: set fire to the Phosphorus, and immerse it in the bottle, till it reaches half way down. The Phosphorus will burn with so much splendour and rapidity, that the eye can scarcely bear it; at the same time great heat will be evolved, and the sides of the vessel will be encrusted with a white flaky substance, called Phosphoric Acid.

DXLI.

THE COMBUSTION OF BORON IN OXYGEN GAS, *Is very splendid.*

If a small piece of Boron be heated to 560° in a Platinum spoon, and introduced into a jar of Oxygen Gas, it will burn with the greatest brilliancy, and by Combination with the Oxygen will be converted into Boracic Acid, *Observation.* The affinity of boron for oxygen, is so great at this temperature, as to separate it from any other substance.

DXLII.

HOMBERG'S PYROPHORUS BURNS WITH MUCH BRILLIANCY *In Oxygen Gas.*.

Pour into a jar of Oxygen Gas, about a scruple of Homberg's Pyrophorus. This inflammable substance will take fire the instant it enters the jar; the ignition will be accompanied by a slight explosion.

DXLIII.

THE COMBUSTION OF SODIUM IN OXYGEN GAS *Is very Brilliant.*

If a small portion of Sodium be heated nearly red-hot in an iron spoon, and in this state immersed in a jar of Oxygen Gas, a very beautiful and brilliant Combustion, attended by rapid scintillations and vivid flame, will take place. The product will be Oxide of Sodium, or Soda.

Observation. In this experiment as well as in the following, an iron instead of a platinum spoon should be used, as the sodium and potassium in an oxidised state, (that is in the Alkaline state,) act very strongly on Platinum.

DXLIV.

POTASSIUM ENTERS INTO VIVID COMBUSTION, WHEN *Heated in Oxygen Gas.*

Potassium has great affinity for Oxygen, and abstracts it from many other substances. If a small quantity receives something below a red heat in a jar of Oxygen Gas, by means of a burning lens, (see Plate 3,) it takes fire, and burns with most vivid light and intense heat; forming the Peroxide of Potassium, or Potass.

DXLV.

TIN BURNS BRILLIANTLY IN OXYGEN GAS.

Heat some granulated Tin considerably, in a Platinum spoon, and in this state immerse it in Oxygen Gas; a very beautiful Combustion, attended by a brilliant white light, will instantly take place; when Oxide of Tin will be formed.

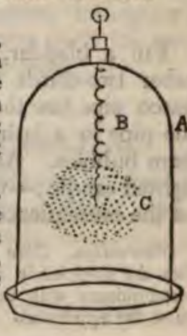
DXLVI.

Combustion of Iron Wire in Oxygen Gas.

If an Iron-wire twisted in the form of a corkscrew, (or in a straight, or any other form,) having the end of an ignited Sulphur match attached to it, be plunged into a jar of Oxygen gas, a beautiful and rapid scintillating Combustion in a spiral direction will take place, forming Oxide of Iron.

Observations. In this and similar experiments, the heat is so great, that if, upon sudden agitation of the jar, a drop of the melted metal should strike against its side, the glass will be perforated in an instant; and the drop will appear on the table: sometimes the globule only effects a permanent lodgement in the side of the jar.

The annexed figure illustrates this experiment. A, Is the jar, containing the oxygen gas. B, the twisted iron wire. C, the end of the wire in a state of combustion. Under the jar is a saucer, containing water to prevent the escape of the gas.



DXLVII.

Zinc burns brilliantly in Oxygen Gas.

If a piece of Zinc be put into the Platinum spoon with a very small piece of Phosphorus, and the Phosphorus set on fire; and if, in this state, the spoon be immersed in a jar of Oxygen Gas, Combustion will be soon communicated to the metal, which will burn with a greenish flame, forming Oxide of Zinc.

Observation. Zinc-filings or turnings will, perhaps, answer the purpose better, as the particles in a divided state are more liable to combustion, than a piece of the metal.

DXLVIII.

Arsenic burns vividly in Oxygen Gas.

Put a small piece of Arsenic into the Platinum spoon with a piece of Phosphorus, the size of a split pea. Set fire to the Phosphorus, and introduce the spoon quickly into a jar of Oxygen Gas: the Phosphorus will soon fire the the metal, which will burn with much brilliancy, giving out white fumes, which will attach themselves to the sides of the jar.

Observation. These fumes are Arsenic Acid, the same as that known by the name of white arsenic. The filings of arsenic may, perhaps, answer the purpose better. In either case, the metal must be used: this is mentioned in order to distinguish between arsenic acid and arsenic, the latter being the metal, in the reguline state.

DXLIX.

HYDROGEN AND OXYGEN GASES BURN AND DETONATE,

When mixed together.

Fill a bladder, about one-third with Oxygen, and the other two-thirds with Hydrogen Gas; affix a brass tobacco pipe (see the figure in page 287,) to the bladder: dip the pipe in a lather of Soap, and press the bladder so as to form bubbles. As they ascend in the air, inflame them by a lighted candle:—vivid Combustion and loud Detonation will be the consequence.

Observation. Care must be taken not to inflame the bubbles, until they are completely detached from the bowl, because the flame may communicate with the gases in the bladder, which would, of course, burst the apparatus.

DL.

THE COMBUSTION OF SULPHURETTED HYDROGEN

With Oxygen Gas, is attended by Detonation.

Fill a bladder, having a pipe and stop-cock, with two-fifths of Sulphuretted Hydrogen, and three-fifths of Oxygen Gas: dip the pipe in Soap-suds, and blow bubbles by pressing the bladder between the hands; the bubbles will ascend, and may be inflamed by a lighted candle. These bubbles detonate at the time of inflammation.

Observation. The products of this combustion are water and sulphurous acid.

DLI.

COMBUSTION OF PHOSPHURETTED HYDROGEN GAS

With Oxygen Gas.

Prepare a jar of Oxygen Gas, and pass into it, through water, a few globules of Phosphuretted Hydrogen Gas: Combustion and detonation will take place. This may be repeatedly done, until the whole of the Oxygen in the jar is expended. Phosphoric Acid will be found on the sides of the jar.

Observation. This experiment may be varied by preparing two bladders with stop-cocks, and filling them, one with oxygen, and the other with phosphuretted hydrogen gas. As the stop-cock of one bladder is opened, let an assistant turn that of the other so close to it, that the two streams of gas may be emitted side by side, and inflamed.

The following Experiments illustrate the capability of some Compound Gases, containing Oxygen, to support Combustion. In all these Cases, the Oxygen quits its former Combination to unite with the burning body.

DLII.

INFLAMED CHARCOAL BURNS IN NITROUS GAS.

Inflame a piece of Charcoal, and immerse it, by means of a wire, in a jar of Nitrous Gas; a very brilliant combustion will be the consequence.

DLIII.

HOMBERG'S PYROPHORUS BURNS IN NITROUS GAS.

Pour some of Homberg's Pyrophorus into a jar containing Nitrous Gas; a very beautiful stream of fire, will be seen to flow to the bottom of the jar.

DLIV.

NITROUS GAS DOES NOT SUPPORT THE COMBUSTION *Of a Taper or Candle.*

Immerse a lighted taper or candle in a jar of Nitrous Gas; it will instantly be extinguished.

Observation. In the two foregoing and three following experiments, the substances employed were elevated to so high a temperature, as to separate the oxygen from the nitrous gas; it is not so with the flame of a candle, which cannot destroy the affinity which exists between the nitrogen and oxygen.

DLV.

PHOSPHORUS BURNS IN NITROUS GAS.

Set fire to a piece of Phosphorus, and immerse it, (in a Platinum spoon,) in a jar of Nitrous Gas: a very brilliant Combustion will now take place, and Phosphorous Acid will be formed; at the same time that Nitrogen Gas will be disengaged.

Observation. That nitrogen exists in the gas, may be proved by the extinction of the flame of a taper when immersed in it.

DLVI.

HYDROGEN BURNS WHEN MIXED WITH NITROUS GAS.

Fill a stout phial with Nitrous and Hydrogen Gases, in equal proportions, set fire to the Gases at the mouth of the phial. Flame of a green colour will pervade it.

DLVII.

SULPHURETTED HYDROGEN WILL BURN WHEN MIXED *With Nitrous Gas.*

Let a bladder be filled with three-fifths of Sulphuretted Hydrogen Gas, and two-fifths of Nitrous Gas. If Soap-bubbles are blown with this compound, they will explode and burn with a light-green flame, when a lighted candle is brought in contact with them.

Observation. If these proportions are mixed in a jar, and inflamed, a greenish flame will pervade the whole of the vessel.

DLVIII.

NITROUS ACID GAS SUPPORTS COMBUSTION.

Immerse a burning taper in a jar of Nitrous Acid Gas; the flame will be enlarged, and it will burn brilliantly.

DLIX.

PHOSPHORUS BURNS IN NITROUS ACID GAS.

If a piece of inflamed Phosphorus be plunged in a jar of Nitrous Acid Gas, a very beautiful and brilliant Combustion will be the consequence.

DLX.

CHARCOAL, AND HOMBERG'S PYROPHORUS, BURN IN *Nitrous Acid Gas.*

Immerse a piece of ignited Charcoal in a jar of Nitrous Acid Gas: it will burn with a dull red flame; but if some of Homberg's Pyrophorus be poured into a jar of this Gas, a brilliant stream of fire will flow to the bottom.

DLXI.

A TAPER BURNS BRILLIANTLY IN NITROUS *Oxide Gas.*

Prepare a jar of Nitrous Oxide Gas, and immerse in it a lighted taper; the flame will instantly be rendered more vivid, and as the taper burns, slight detonations will be heard.

Observation. When the gas has been nearly expended, the external film or flame will be of a very beautiful azure hue.

DLXII.

CHARCOAL BURNS IN NITROUS OXIDE GAS.

If a piece of red-hot Charcoal be introduced into a jar of Nitrous Oxide Gas, it will burn with almost the same brilliancy that it does in Oxygen Gas.

DLXIII.

IRON-WIRE BURNS VIVIDLY IN NITROUS OXIDE GAS.

Attach a small piece of Phosphorus to a spiral wire, similar to that used for Combustion in Oxygen Gas; set fire to the Phosphorus, and when in a state of inflammation, introduce it into a large jar of Nitrous Oxide Gas: a very beautiful scintillating Combustion, with much splendour, will take place.

DLXIV.

PHOSPHORUS BURNS WITH GREAT RAPIDITY

In Nitrous Oxide Gas.

Immerse a piece of ignited Phosphorus in a jar of Nitrous Oxide Gas; it will burn remarkably quick, and with astonishing splendour.

Observation. If a small piece, of double the size of a pin's head, be put in a platinum spoon immersed in the gas, and a thick iron-wire heated to whiteness, be brought in contact with it, an explosion will be the consequence.

DLXV.

THE COMBUSTION OF SULPHUR IN NITROUS OXIDE GAS,

Is attended by beautiful phenomena.

Dip a long slip of Wood in melted Sulphur, so that one-half, upwards, may be covered. Light it, and whilst burning with a weak bluish flame, introduce it into a jar of Nitrous Oxide Gas: the flame will be instantly extinguished. Withdraw the match, inflame it again, and let it burn for two or three seconds until the flame be vivid, then immerse it once more. Instead of extinction, the flame will be now kept up with great splendour. It will be of a delicate red colour.

DLXVI.

ZINC-FILINGS BURN IN NITROUS OXIDE GAS.

Put some Zinc-filings into a Platinum spoon; and with them, a small piece of Phosphorus: set the Phosphorus on fire, and immediately plunge the whole into a jar of Nitrous Oxide Gas. Combustion will be communicated to the Zinc, which will accordingly give out a greenish flame.

DLXVII.

BEAUTIFUL COMBUSTION OF HOMBERG'S PYROPHORUS *In Nitrous Oxide Gas.*

Pour some Homberg's Pyrophorus into a jar of Nitrous Oxide Gas: as it descends, it will appear to be transformed into a stream of fire.

DLXVIII.

HYDROGEN, AND NITROUS OXIDE GASES EXPLODE *When inflamed together.*

Fill a small stout wide-mouthed phial with equal parts of Hydrogen, and Nitrous Oxide Gases: before the phial is removed from the shelf, wrap round it a piece of cloth, or a pocket-handkerchief. Now lift it up quickly, and present the mouth to the flame of a candle; a loud explosion will be the consequence.

DLXIX.

SOAP-BUBBLES INFLATED WITH HYDROGEN AND NITROUS *Oxide Gases, explode when inflamed.*

Half fill a jar with Nitrous Oxide Gas; fill the other half with Hydrogen Gas; and fill a bladder from the mixture. Attach a tobacco-pipe to the bladder, and prepare some soap lather. Dip the bowl of the pipe in the lather, form bubbles, and set fire to them when they have ascended a little way: they will explode with a loud report.

DLXX.

COMBUSTION OF PHOSPHURETTED HYDROGEN, *In Nitrous Oxide Gas, attended by Explosion.*

Prepare a jar of Nitrous Oxide Gas, and pass up into it, a few globules of Phosphuretted Hydrogen Gas, at a time; they will explode the instant they come in contact with the other Gas, exhibiting a very bright flame.

Observations. Phosphate of Ammonia will be the result of this combustion ; for the oxygen of the nitrous oxide, having combined with the phosphorus to form phosphoric acid, leaves the nitrogen to combine with the free hydrogen, and thus form ammonia. But these two substances being unable to retain their gaseous form separately in the same vessel combine and form phosphate of ammonia.

The following Experiments illustrate the capability of Chlorine Gas, and some of its compounds, to support Combustion. In all such cases, the Chlorine combines with the combustible, forming a Chloride.

DLXXI.

A LIGHTED TAPER BURNS WITH MUCH ENERGY *In Chlorine Gas.*

If a lighted taper is immersed in Chlorine Gas, Combustion will be most actively continued ; and will be accompanied by red flame, and a copious emission of dense fumes, as long as any of the Gas remains in the jar, in a state of purity.

DLXXII.

COMBUSTION OF CHARCOAL-POWDER IN CHLORINE.

Pour some dry Charcoal, newly made and finely powdered, into a jar containing Chlorine Gas : a very beautiful combustion will take place, displaying a stream of fire.

DLXXIII.

PHOSPHORUS BURNS SPONTANEOUSLY IN *Chlorine Gas.*

If a bottle be filled with Chlorine Gas and a bit of Phosphorus be introduced into it, it will take fire spontaneously, burning with a light-green flame, but without affording so much light as in Oxygen Gas : the product will be a white substance, which adheres to the sides of the vessel, and is the Proto-chloride of Phosphorus.

Observation. The proto-chloride is that state of combination, in which the phosphorus unites with the least quantity of chlorine.

DLXXIV.

BORON IS COMBUSTIBLE IN CHLORINE GAS.

If a small quantity of Boron is introduced into a jar or bottle, filled with Chlorine Gas, it takes fire and burns with a most splendid flame; and as the combustion goes on, the Chlorine and Boron are deposited on the sides of the vessel in the form of Chloride of Boron.

DLXXV.

MERCURY BURNS IN CHLORINE GAS.

A very brilliant combustion takes place if Mercury in a Platinum spoon, be heated in a jar of Chlorine Gas; Chloride of Mercury will be formed.

DLXXVI.

POTASSIUM BURNS WHEN HEATED IN *Chlorine Gas.*

Put a globule of Potassium into an Iron spoon, and immerse it in a jar containing Chlorine Gas; heat it by means of a burning lens, to about 70° of Fahrenheit: a very splendid combustion will take place, and Chloride of Potassium will be formed.

Observation. It is best to immerse the Potassium by means of an iron spoon, as a platinum one would be corroded by the action of the chloride.

DLXXVII.

SODIUM IS COMBUSTIBLE IN CHLORINE GAS.

If a small quantity of Sodium in a Platinum spoon, be immersed in a jar of Chlorine Gas; rapid combustion, with red sparks and flame, will take place: the product will be Chloride of Sodium.

DLXXVIII.

TIN BURNS IN CHLORINE GAS.

Put some Granulated Tin, or Tin-filings, heated to about 80°, into a Platinum spoon, and immerse them in a jar of Chlorine Gas. Immediate combustion, attended by a bluish white flame, will take place, forming Chloride of Tin.

Observation. This experiment may be varied by immersing a piece of tinfoil, hung upon a platinum-wire, in a jar of this gas.

DLXXIX.

SILVER-LEAF BURNS IN CHLORINE GAS.

Put a piece of Silver-leaf on the hooked end of a Platinum wire; heat it to about 80° or 100°, and in this state immerse it in a jar of Chlorine Gas. Combustion, with a brilliant white flame, will take place, forming Chloride of Silver.

Observation. The same phenomenon will result, by using the filings of Silver.

DLXXX.

GOLD-LEAF BURNS IN CHLORINE GAS.

If Gold-leaf be heated to about 100°, and immersed in a jar of Chlorine Gas, combustion, with a beautiful green flame will take place. Chloride of Gold will be formed.

DLXXXI.

BISMUTH IS COMBUSTIBLE IN CHLORINE GAS.

Put a few Bismuth-filings into a Platinum spoon, heat them to about 80°, and immerse them in a jar of Chlorine Gas. Combustion will take place, attended by a blue light. Chloride of Bismuth will be formed.

DLXXXII

ARSENIC IS COMBUSTIBLE IN CHLORINE GAS.

Put some filings of Arsenic into a Platinum spoon, heat them to about 80°, and immerse them in a jar of Chlorine Gas. Combustion will take place, attended by beautiful scintillations and a greenish flame.

Observation. Chloride of arsenic will be formed in dense white fumes.

DLXXXIII.

IRON WILL BURN IN CHLORINE GAS.

Put some Iron-turnings into a Platinum spoon, heat them to about 200°, and immerse them in a jar of Chlorine Gas. Combustion, attended by a vivid red light, will take place, forming Chloride of Iron.

DLXXXIV.

COBALT BURNS IN CHLORINE GAS.

Put some Cobalt-filings into a Platinum spoon, heat them to 200°, and immerse them in a jar of Chlorine Gas. Combustion, with a pale blue light will be the consequence, forming Chloride of Cobalt.

DLXXXV.

LEAD IS COMBUSTIBLE IN CHLORINE GAS.

Into a Platinum spoon put a few filings of Lead, heat them to 80°, and immerse them in a jar of Chlorine Gas. Combustion will take place, attended by a lambent white flame. Chloride of Lead will be the product.

DLXXXVI.

COPPER BURNS IN CHLORINE GAS.

Put some Copper-filings into a Platinum spoon, heat them to 180°, and immerse them in Chlorine Gas. The filings will burn with a dull red flame. Chloride of Copper will be the result.

DLXXXVII.

ANTIMONY BURNS IN CHLORINE GAS.

If Filings of Antimony, are heated to about 80°, and immersed in a jar containing Chlorine Gas, rapid scintillating combustion, with a white flame, will take place. Chloride of Antimony will be formed.

DLXXXVIII.

ZINC IS COMBUSTIBLE IN CHLORINE GAS.

Put some Filings of Zinc, heated to about 80° Fahrenheit, into a Platinum spoon, and immerse them in a jar of Chlorine Gas. Vivid combustion will take place, accompanied by brilliant scintillations. Chloride of Zinc will be formed.

DLXXXIX.

NICKEL BURNS IN CHLORINE GAS.

If small pieces of Nickel heated to about 200°, be put into a Platinum spoon and placed in a jar of Chlorine Gas, brilliant combustion will take place, and Chloride of Nickel will be formed.

DXC.

TELLURIUM IS COMBUSTIBLE IN CHLORINE GAS.

If small pieces of heated Tellurium are introduced into a jar of Chlorine Gas, they will instantly take fire, and burn with a greenish flame. Chloride of Tellurium will be the product.

DXCI.

COMBUSTION OF DUTCH METAL IN CHLORINE GAS.

Hang upon a hooked wire a leaf of Dutch Metal, and immerse it in a jar of Chlorine Gas; a very beautiful combustion will take place: Chloride of Copper will be formed.

DXCII.

PHOSPHURETTED HYDROGEN GAS BURNS IN *Chlorine Gas.*

Having prepared Phosphuretted Hydrogen Gas in a retort, place the beak under a jar of Chlorine, placed upon a shelf over Mercury. As the globules ascend, they will inflame and detonate.

Observation. When a few globules have passed up, the beak should be withdrawn, as a greater quantity at one time, might, by its explosion, burst the apparatus. The products of this combustion are chloride of phosphorus, and hydro-chloric acid;—part of the chlorine combining with the hydrogen, and part with the phosphorus.

DXCIII.

ANTIMONY BURNS IN PROT-OXIDE OF CHLORINE.

Heat some Filings of Antimony, gently, in a Platinum spoon, and immerse them in a jar containing Prot-oxide of Chlorine. Combustion, attended by a dull yellowish white light, will be the consequence.

DXCIV.

COPPER BURNS IN PROT-OXIDE OF CHLORINE.

Heat some Copper-filings in a Platinum spoon, and immerse it in a jar of Prot-oxide of Chlorine. Combustion, attended by a dull red light, will be the consequence.

DXCV.

COMBUSTION OF CHARCOAL IN PROT-OXIDE OF CHLORINE.

Kindle a piece of Charcoal, place it in a Platinum spoon, and immerse it in a jar of Prot-oxide of Chlorine. It will burn with a dull reddish light.

DXCVI.

COMBUSTION OF PHOSPHORUS IN PROT-OXIDE OF *Chlorine.*

Place a small piece of Phosphorus in a Platinum spoon, and immerse it in a jar of Prot-oxide of Chlorine. Explosion and rapid combustion will be the consequence.

DXCVII.

EXPLOSION AND COMBUSTION OF PHOSPHORUS IN *Per-oxide of Chlorine.*

Introduce a Platinum spoon, containing a piece of Phosphorus, of the size of a pea, into a jar containing Per-oxide of Chlorine. Detonation, and decomposition of the Per-oxide will be the consequence.

Observations. It is remarkable, that even after the decomposition, the phosphorus continues to burn with much splendour in the oxygen and chlorine gases, which have been separated from each other. The per-oxide of chlorine, is in the highest state of oxygenation of which the chlorine is capable.

The following Experiments prove the power which other Gases, besides those already mentioned, have of supporting Combustion.

DXCVIII.

POTASSIUM IS COMBUSTIBLE IN IODINE VAPOUR.

Immerse a small globule of Potassium, by means of an Iron spoon, in a jar containing the Vapour of Iodine. It will burn with a beautiful violet-coloured flame, and Iodide of Potassium will be formed.

Observation. If this compound be heated in a jar of chlorine gas, chloride of potassium will be the product; the iodine being set free.

DXCIX.

POTASSIUM BURNS IN SILICATED-FLUORIC GAS.

Put a globule of Potassium into an Iron spoon, and heat it gently in a jar of Silicated Fluoric Gas. Combustion, with a beautiful reddish light, will take place.

Observation. The silicated fluoric acid gas is here prescribed, because of the impossibility of obtaining pure fluoric acid gas, in a glass jar, where an experiment of this nature must be performed. The usual mode of obtaining and preserving this gas, and the acid of the same name, is by using a leaden retort and receiver ; also a leaden bottle to hold it after it is prepared. When it is prepared in a glass retort, or preserved in a glass jar, it acts so rapidly on the silica of the glass as not only to corrode and detroy its transparency, but frequently to perforate it with holes. In these cases, the gas itself is converted into silicated fluoric gas.

DC.

SULPHURETTED HYDROGEN GAS SUPPORTS COMBUSTION.

Heat a globule of Sodium (in an Iron spoon,) in a jar of Sulphuretted Hydrogen Gas. A very beautiful combustion will take place, and Hydrogen Gas will be evolved.

Observation. Here the sulphur and the metal combine, forming sulphuret of sodium, which is a reddish substance.

DCI.

POTASSIUM BURNS IN SULPHURETTED HYDROGEN GAS.

A globule of Potassium heated in this Gas, will enter into vivid combustion. Sodium treated in the same way will present similar phenomena and results.

Observation. The sulphuretted hydrogen gas may be recovered from these sulphurets by the action of acids.

DCII.

POTASSIUM BURNS IN THE VAPOUR OF SULPHURET OF *Carbon.*

Pour a few drops of Sulphuret of Carbon into a Florence flask, place it over a lamp, and apply a gentle heat; then immerse, by means of an Iron spoon, a globule of Potassium in the vapour arising from it. Combustion, with a red flame, will be the consequence: and Sulphuret of Potassium will be formed. Allow some of the vapour to escape, before the metal is submitted to its action.

Observation. A globule of Sodium treated in the same way will afford similar phenomena and results.

DCIII.

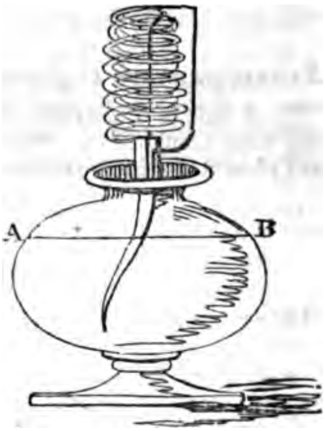
HEATED PLATINUM-WIRE BECOMES RED HOT WHEN *Held in the Vapour of Sulphuric Ether.*

Pour half a dram of Sulphuric Ether into a wine-glass, and twist a piece of Platinum-wire of the fineness of a sewing-thread, in the form of a screw, round the finger: when it has received a spiral form, hold it in the flame of a candle until it be red-hot; when the redness is considerably abated, if held over the wine-glass, it will be immediately resumed, and kept up as long as the Ether continues to ascend in the state of vapour. The experiment succeeds better, if, when the wire is heated, the candle be withdrawn; when the appearance in the dark will be phosphorescent.

Observations. On this experiment is founded the interesting one of the preparation of a lamp which exhibits light without flame.

LAMP WITHOUT FLAME.

Around the tube of a small alcohol-lamp twist a piece of Platinum-wire, one hundredth part of an inch in diameter; and form about ten or a dozen convolutions above the tube with the same piece. This may be done by previously twisting the wire around a tobacco-pipe. Let the cotton-wick be small, having its fibres loose, and standing perpendicular in the tube, but no higher than the third or fourth convolution. The coils towards the top should gradually become smaller as they approach it. The lamp should be a little more than half filled with alcohol, ether, or even camphor. Light the wick, and when the upper coils become red-hot, blow it out: all the wire above the wick will now arrive at a white heat, and continue to give out a most brilliant light as long as the alcohol, &c. continues to ascend by the capillary attraction of the cotton. In a dark room, a gentle lambent flame will be seen playing round the wire. The annexed is a figure of this lamp.



A, B, Is the level of the spirits or other combustible fluid in the lamp.

This lamp evolves a degree of light not only sufficient to read the smallest characters, but it radiates with the intense splendour of substances undergoing combustion in oxygen gas, and is attended by heat so powerful that the alcohol often takes fire, and the lamp is spontaneously re-lighted within a few seconds after being extinguished.

Lamps of this construction are sold by the Philosophical instrument-makers for six shillings each.

DCIV.

VARIATION, IN THE VAPOUR OF CAMPHOR.

If a piece of Camphor, or a few small fragments of this inflamable substance in a heap, be placed in any convenient situation, as on a shilling, the bottom of a glass, &c.; and a piece of Platinum wire, either coiled or pressed up together, be heated and laid upon it, the Platinum will glow brilliantly, as long as any Camphor remains, and will frequently light it up into a flame.

Besides the Gases and Vapours above mentioned, the extraordinary fact has been ascertained that Steam from Water will give much brilliancy and intensity to the light and heat proceeding from burning bodies.

Mr. J. F. Dana, has published, in Professor Silliman's Journal, that when a jet of Steam issuing from a small aperture, is thrown on burning Charcoal, the brightness is increased, if the coal be held at the distance of four or five inches from the pipe through which the Steam passes; but, if the coal be held nearer, it will be extinguished: a circular black spot first appearing where the Steam is thrown on it. The Steam in this case does not appear to be decomposed, and the increased brightness of the coal depends probably on a current of atmospheric air, occasioned by the Steam. But, when a jet of Steam, instead of being thrown on a single coal, is made to pass into a Charcoal fire, the vividness of the combustion is increased, and the low attenuated flame of coal is enlarged.

When the wick of a common oil-lamp is raised, so as to give off large columns of smoke, and a jet of Steam is thrown into it, the brightness of the flame is increased, and no smoke is thrown off. When Spirits of Turpentine are made to burn on a wick, the light produced is dull and reddish, and a large quantity of thick smoke is given off; but when a jet of Steam is thrown into this flame, its brightness is much increased; and, when the experiment is carefully performed, the smoke entirely disappears. When the vapour of Spirits of Turpentine is made to issue from a small orifice, and is inflamed, it burns, and throws off large quantities of smoke; but, when a jet of Steam is made to unite with the vapour, the smoke entirely disappears. When vapour of Spirits of

Turpentine, and of Water, are made to issue together from the same orifice, and are inflamed, no smoke appears. Hence its disappearing in the above experiment, cannot be supposed to depend on a current of atmospheric air.

When a jet of Steam is thrown into the flame of a Spirit-of-wine lamp, or into flames which evolve no smoke or Carbonaceous matter, the same effect, is produced as by a current of air. It appears from these experiments, that, in all flames which evolve smoke, Steam produces an increased brightness, and a more perfect combustion. "Now, (says Mr. D.) with a very simple apparatus, Steam might be introduced into the flames of street-lamps, and into all flames which evolve much smoke. The advantages of such an arrangement would be, a more perfect combustion, and a greater quantity of light from the same materials." The flame of the lamps to which Steam is applied, might be made to keep the water boiling which supplies the Steam, in the same manner that the *Alcohol blow-pipe* mentioned in this work, and exhibited in Plate 9, distils and burns its own vapour.

CHAPTER XIII.

EXPERIMENTS ON THE PREPARATION AND USES OF FULMINATING AND DETONATING COMPOUNDS.

THE most remarkable instances of Expansion by Heat with which we are acquainted, are those where Explosive Mixtures are used, and where Reverberation of the Air is the consequence. In the explosion of these compounds (which are of various kinds), the simple substances of which they are composed are either resolved into their primary states, or they immediately enter into combination with other substances, which, like themselves, have just been liberated. In most cases, they not only assume but retain the elastic form. The explosion of these bodies is doubtless owing to their combination with heat: but whether the heat has been *latent* in themselves, or whether they are capacitated, by a slight elevation of temperature, suddenly to rob the surrounding atmosphere of its heat, is not known.

It is remarkable that Nitrogen is a component part of most explosive mixtures Explosion, or the Reverberation of Air, is merely a consequence of their sudden expansion, or assumption of the elastic form.

The general causes of Explosion in the following Experiments, are Heat, Inflammation, Friction or Percussion, and Mixture.

DCV.

DEFLAGRATION OF NITRIC ACID WITH OIL OF TURPENTINE.

If 1 ounce of Oil of Turpentine be poured into a gallipot (placed in the open air), and 1 ounce of Nitric Acid, with 20 drops of Sulphuric Acid, into a phial tied to the end of a walking-stick; the Acid, on being thrown upon the Oil (at arm's length, to prevent accident) will cause Deflagration:—abundance of Light and Heat being evolved.

DCVI.

SULPHURIC ACID DEFLAGRATES WITH RED-HOT CHARCOAL.

Cover up some small pieces of Charcoal in a crucible, and give them a red heat. When perfectly hot, uncover the crucible, and pour some Sulphuric Acid upon them from a phial tied to the end of a stick; immediate Deflagration will take place from the rapid decomposition of the Acid, part of which will be thrown out, by the quick disengagement of Carbonic Acid Gas. When the action has subsided, Sulphur will be found precipitated on the Charcoal. Here the Charcoal, in the red-hot state, has more affinity for Oxygen, than Sulphur has in the state of Sulphuric Acid; the consequences are, the formation of Carbonic Acid and the precipitation of Sulphur.

DCVII.

INSTANTANEOUS EXPANSION OF WATER WHEN HEATED SUDDENLY.

If a tea-spoon-full of Water be thrown into a ladle or other vessel containing boiling Oil or Fat, a number of rapid Explosions will take place from the sudden expansion of the Water. Here, the Oil requiring greater heat to make it boil than Water does; the Water is rapidly converted into Steam, by depriving the Oil of part of its Caloric. Consequently, the quantity of Caloric is so great, and the expansion so sudden, that in addition to the reverberation of the Air, some of the contents of the vessel will be thrown out.

DCVIII.

DECOMPOSITION OF STEAM FROM WATER, BY MELTED ANTIMONY, ATTENDED BY EXPLOSION.

Melt some Antimony in a crucible, and when at a white heat, pour some Water into a small retort, and hold it over a lamp. When the Steam passes out, hold it over the crucible containing the Antimony, so that the Steam may enter into or pass over it. At this instant, let an assistant agitate the crucible by a pair of tongs: a series of very violent Explosions will take place, as the Water, in the form of Steam, is decomposed. Here the Oxygen combines with the Metal, and the Hydrogen is set free.

DCIX.

SULPHUR DEFLAGRATES WITH MELTED NITRATE OF POTASS.

Melt 4 drams of Nitrate of Potass in a crucible, and when it is completely fused, throw in 2 drams of Sulphur, in powder; Deflagration will be the consequence. Here the Salt will be decomposed, and Sulphate of Potass will be found in the crucible.

DCX.

TO MAKE GUNPOWDER.

Pulverize separately, 5 drams of Nitrate of Potass, 1 dram of Sulphur, and 1 dram of newly-burnt Charcoal: mix them together in a mortar, with a little Water, so as to make the compound into a dough, which roll out into round pieces, of the thickness of a pin, upon a slab; this must be done by moving a board backwards and forwards until the dough is of a proper size. When three or four of these strings, or pieces are ready, put them together and with a knife cut the whole off in small grains. Place these grains on a sheet of paper, in a warm place; they will soon dry. During granulation, the dough must be prevented from sticking, by using a little of the dry compound powder. This mode of granulation, though tedious, is the only one to be used for so small a quantity, for the sake of experiment: in the large way, Gunpowder is granulated by passing the composition through sieves.

DCXI.

COMMON FULMINATING POWDER.

Mix together 1 dram of Sulphur, 3 drams of Nitrate of Potass, and 2 drams of Carbonate of Potass (all previously pulverised) in a sheet of writing-paper. When properly mixed, put them into a small stoppered phial. An eighth, or a sixteenth part of this, put on a fire-shovel, or tin plate, held over the fire for a few minutes, will explode; immediately before the explosion, a violet-coloured flame will be seen to hover round it.

DCXII.

A COMPOUND OF NITRATE OF POTASS, SULHPUR, AND SULPHURET OF ANTIMONY, DEFLAGRATES WHEN SLIGHTLY INFLAMED.

Reduce separately to fine powder, 4 ounces of Nitrate of Potass, 2 ounces of the Sulphuret of Antimony, and 1 ounce of Sulphur; mix them well on a sheet of paper with a wooden or ivory spatula, and preserve the compound in a dry phial. When it is to be used, lay about a dram, or more, on a piece of wood or iron, and fire it with a red-hot iron wire; instant Deflagration, accompanied by dazzling light and great heat, will take place.

DCXIII.

SULPHURET OF ANTIMONY AND NITRATE OF POTASS, DEFLAGRATE AT A RED HEAT.

Pulverize 4 drams of Nitrate of Potass and the same quantity of Sulphuret of Antimony; combine them, and throw about a dram of the mixture into a red-hot crucible; immediate deflagration will be the consequence. If we continue to deflagrate the compound until the whole is exhausted, some of the revived metal (Antimony) will be found at the bottom of the crucible. If the Nitrate of Potass be first melted, and the Sulphuret then thrown in; the Deflagration will be the same.

DCXIV.

CHARCOAL DEFLAGRATES WITH MELTED NITRATE OF POTASS.

If 4 drams of Nitrate of Potass are made hot in a crucible, and 2 drams of powdered Charcoal are thrown into it in this state, a most beautiful explosion and combustion will take place. The new products are Carbonic Acid Gas, Carbonate of Potass, and Nitrogen Gas; the second is stationary, whilst the first and third fly off. The decomposition is obvious. The Charcoal combines with the Oxygen of the Nitric Acid, forming Carbonic Acid, which seizes on the Potass (now free), whilst the Nitrogen, combining with Caloric, forms Gas.

DCXV.

Charcoal and Nitrate of Potass deflagrate when inflamed by a Red-hot Iron.

Pulverise 2 drams of Nitrate of Potass and 1 dram of Charcoal; mix them together, and put them on a fire-shovel in the chimney-corner, or on the side of the grate. Touch the compound with a red-hot iron wire, very brilliant combustion will be the consequence. The Nitrate will, of coure, be decomposed, and the Charcoal, uniting with its Oxygen, will be converted into Carbonic Acid, part of which will combine with the Potass; another part will be evolved, as will also the Nitrogen Gas, which has been set free by the decomposition.

DCXVI.

Plumbago (Carburet of Iron) deflagrates with melted Nitrate of Potass.

Into a crucible containing a little melted Nitrate of Potass, throw some powdered Plumbago; deflagration will be the consequence. This experiment may be varied by mixing the two substances in powder, and throwing them into a hot crucible. The Carbon will fly off in the state of Carbonic Acid, and Oxide of Iron will remain.

DCXVII.

Phosphorus deflagrates with melted Nitrate of Potass.

If 6 grains of Phosphorus be thrown into a crucible, containing 3 drams of red-hot melted Nitrate of Potass, a very violent detonation and very beautiful combustion will take place. Nitrogen Gas and Phosphate of Potass will be formed.—Similar effects result from the action of Phosphorus on melted Nitrate of Soda.

DCXVIII.

Percussion causes the Explosion of Phosphorus and Nitrate of Potass.

A mixture of 10 grains of powdered Nitrate of Potass with 2 grains of Phosphorus, will produce a very violent explosion when struck on an anvil by a hot hammer. Nitrogen Gas, Phosphoric Acid, and Phosphate of Potass, are the results of this decomposition. The same phenomena take place when Phosphorus is combined with Nitrate of Soda, and struck in the same way.

DCXIX.

Percussion causes the Explosion of Sulphur with Nitrate of Silver, and Reduction of the Metal.

Reduce to powder 10 grains of Nitrate of Silver, and then mix with it 4 grains of Sulphur; wrap the mixture in a small bit of paper, and place it upon an anvil; warm a hammer which has a broad surface, pretty hot, and strike the mixture with it; a violent explosion will take place, and upon examination, the Silver will be found in a reduced or metallic state. If the hammer be cold, the Sulphur, only, will be affected; it will then inflame without Detonation.

Observation. Here, when the metal resumes its original form, nitrogen quits the salt, and becomes gaseous from combination with the caloric evolved in the decomposition; the oxygen of the nitric acid being also free, combines with the sulphur, and flies off in the state of sulphurous acid gas.

DCXX.

Percussion causes the Explosion of Charcoal and Nitrate of Silver, with Reduction of the Metal.

If 10 grains of Charcoal, in powder, be mixed with 10 grains of Nitrate of Silver, also in powder, and laid on an anvil, wrapped up in paper, an explosion will take place when they are smartly struck by a hot hammer.

Observation. Here the nitrogen of the salt having combined with the caloric evolved by the percussion, flies off in the state of gas; the oxygen and charcoal also assume the gaseous form, being converted into carbonic acid gas, whilst the metal is restored to its former properties, or is left partially oxidised.

DCXXI.

Nitrate of Silver and Phosphorus explode, when struck upon an Anvil.

If 6 grains of the Nitrate of Silver are powdered and mixed with 2 grains of Phosphorus in a piece of writing-paper, then put upon an anvil and struck with a hammer, a very violent explosion will take place. Nitrogen and Phosphoric Acid will be disengaged.

DCXXII.

NITRATE OF AMMONIA EXPLODES BY HEAT.

Place a crystal of Nitrate of Ammonia on a shovel, and hold it over the fire; when it has arrived at a heat sufficient for melting Lead, it will, in the act of decomposition, explode with considerable violence.

DCXXIII.

PERCUSSION CAUSES THE DETONATION OF NITRATE OF COPPER WITH PHOSPHORUS.

Place 12 grains of Nitrate of Copper, in powder, mixed with 2 grains of Phosphorus, upon an anvil, and strike them with a hot hammer; detonation will be the consequence. The Salt will be decomposed, giving out Nitrogen Gas. Phosphoric Acid Gas also will be formed, from the union of the Phosphorus with the Oxygen of the Nitrate.

DCXXIV.

TRITURATION CAUSES EXPLOSION OF NITRATE OF LEAD AND SULPHUR, WITH REDUCTION OF THE METAL.

If a pestle and mortar are for some time kept warm before the fire, and a ready-formed mixture of 12 grains of Sulphur and 12 grains of Nitrate of Lead, be thrown in, and smartly triturated, explosions will take place. The Lead will resume its metallic state, whilst Nitrogen, and Sulphurous Acid Gas will be evolved.

DCXXV.

PERCUSSION CAUSES THE EXPLOSION OF NITRATE OF MERCURY AND PHOSPHORUS, WITH REDUCTION OF THE METAL.

If 4 grains of Nitrate of Mercury are reduced to powder, and combined with 2 grains of Phosphorus, a most violent explosion will take place, when they are struck smartly by a hot hammer on an anvil. Globules of reduced Mercury will be found, upon examination of the paper which contained this mixture. Nitrogen Gas and Phosphoric Acid will be disengaged; for the Oxygen of the Salt combining with the Phosphorus, forms Phosphoric Acid, which flies off; the Nitrogen being thus left free, absorbs Caloric, and becomes elastic also, whilst the Metal recovers its properties.

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DCXXXIV.

XPLOSION AND INFLAMMATION TAKE PLACE, WHEN PHOSPHORUS AND CHLORATE OF POTASS ARE THROWN INTO SULPHURIC ACID.

Pour 2 drams of Sulphuric Acid into a gallipot, and
ow into it 4 grains of Chlorate of Potass, and 1 grain
Phosphorus, divided into minute particles. Here, in
lition to the explosion, a very brilliant inflammation
ll take place. In this, and the two following Experi-
its, the combustible materials should be gently
ed with a wooden skewer in the spoon, from which
are to be thrown into the acid.

rvation. A very beautiful effect will be produced by
ing into a gallipot, containing sulphuric acid, 4 grains of
ate of potass, half a grain of phosphorus, half a grain of sul-
and half a grain of charcoal; the flame will be intense, and
xplosion violent.

DCXXXV.

ORATE OF SILVER DEFLAGRATES ON RED-HOT CHARCOAL.

hrow, from the point of a knife, three or four grains
hlorate of Silver on red-hot Charcoal; deflagration
be the consequence, and the Silver will be reduced
metallic state on the Charcoal.

DCXXXVI.

ORATE OF POTASS AND PULVERISED ARSENIC EXPLODE BY PERCUSSION.

Place upon an anvil 2 grains of Chlorate of Potass and
ains of pulverised Arsenic, and strike them smartly
a polished hammer; a very loud explosion, attended
flash of light, will be the consequence. Here the
nsity of heat causes combustion of the metal.

DCXXXVII.

NIC AND CHLORATE OF POTASS ENTER INTO VIVID COMBUSTION, WHEN SLIGHTLY INFLAMED.

s only a small quantity of this powder should be
red at one time, the constituents should be kept in
te phials, and mixed as occasion may require.) Mix
er 5 drams of the Chlorate of Potass and 5 drams

of pulverised Arsenic (the metal) very gently on paper, with a quill or pointed stick, and fire it with a very long match; a very vivid and sudden combustion will take place. If confined, the combustion will be attended by a loud report. In this compound, the Arsenic is the principal combustible.

DCXXXVIII.

CHLORATE OF POTASS AND ARSENIC DEFLAGRATE IN SULPHURIC ACID.

Mix gently in a tea-spoon 3 grains of Chlorate of Potass and 3 grains of pulverized Arsenic (the metal): throw the mixture into a gallipot containing 2 drams of Sulphuric Acid; instant deflagration will take place.

Observation. This experiment may be beautifully varied, by placing the powder on a tile, or flat stone, and dropping on it, at arms length, some sulphuric acid from the end of a feather. Here the explosion will be more violent.

DCXXXIX.

TO PREPARE CHLORIDE OF AZOTE.

Prepare a solution of Nitrate of Ammonia in a very clean jar, so that about one half shall be filled: let this solution be of the temperature of 45° Fahr. Now pass into the jar some Chlorine Gas from a retort containing 1 ounce of Oxide of Manganese and 2 ounces of Muriatic Acid. The Gas will be absorbed almost as rapidly as it ascends, and presently the top of the solution will be covered by a film, which collecting into yellow globules, will fall to the bottom. This is the Chloride of Azote, the most explosive body with which we are acquainted: it is indeed so much so, that great danger is to be apprehended from the employment of more than a globule of the size of a pin's head, in the performance of experiments. This substance should never be touched by any thing which has the least particle of grease or oil on it (except for experiment) as it explodes in an instant, and may do much mischief;—several eminent chemists have been seriously wounded by it. It is best not to make more at one time than is wanted for present experiment.

DCXL.

CHLORIDE OF AZOTE EXPLODES WHEN HEATED.

Put a particle of Chloride of Azote, of the size of a pin's head, into an iron-spoon tied to the end of a long-stick; hold the spoon over a lamp or fire for a few seconds; the Chloride will explode with a very loud report.

DCXLI.

CHLORIDE OF AZOTE EXPLODES WHEN IT COMES IN CONTACT WITH OILS.

Put half a grain of Chloride of Azote into a very clean small delft basin, and pour upon it (from a spoon tied to the end of a long stick) a few drops of Olive, Almond, or any Essential Oil. The instant the Oil falls, a tremendous explosion will take place: the basin will be shattered into a thousand pieces.

DCXLII.

CONTACT OF PHOSPHORUS WITH CHLORIDE OF AZOTE ATTENDED BY TREMENDOUS EXPLOSION.

If half a grain of Chloride of Azote be put gently on half a sheet of clean writing-paper, and a grain of Phosphorus (stuck on the sharpened end of a wire, about a yard long) be brought in contact with it, a most violent explosion will instantly take place. This experiment has been performed in a soup-plate; and the quantities used were 1 grain of each substance. The explosion was so violent as to shatter the plate into a thousand pieces. It is very dangerous to use more than the quantities here mentioned; and particularly so, if the vessel in which the experiment is performed be dirty or greasy It is proper to put the hand before the eyes, whilst this explosion takes place, to prevent the Phosphorus from entering them.

DCXLIII.

CHARCOAL AND IODATE OF POTASS DETONATE BY PERCUSSION.

If 6 grains of Charcoal, in powder, be gently mixed with 6 grains of Iodate of Potass, and laid (folded in a small piece of paper) on an anvil; a smart blow from a hammer, will cause a loud detonation.

DCXLIV.

IODATE OF POTASS DEFLAGRATES WITH RED-HOT CHARCOAL.

Throw a few crystals ot Iodate of Potass on red-hot Charcoal; a very beautiful deflagration will be the consequence. Here the Iodate is decomposed; the Charcoal combines with the Oxygen of the Potass, forming Carbonic Acid; some of which unites with the Potass.

DCXLV.

IODATE OF POTASS DEFLAGRATES WITH MELTED SULPHUR.

Throw a few grains of Iodate of Potass into a crucible, containing a dram of melted Sulphur; violent deflagration will be the consequence: part of the Sulphur being oxygenated, will combine with the Potass, forming Sulphate of Potass; the Iodine will combine with more of the Sulphur, forming Iodide of Sulphur.

DCXLVI.

THE PERCUSSION OF IODATE OF POTASS, OR SODA, WITH SULPHUR, CAUSES EXPLOSION.

When 8 grains of Iodate of Soda or Potass, with 6 grains of Sulphur, are struck upon an anvil, an explosion will take place.

DCXLVII.

IODATE OF POTASS DEFLAGRATES WITH INFLAMED PHOSPHORUS.

Put a piece of Phosphorus into a crucible; when it begins to burn, throw in a few grains of Iodate of Potass; a very violent deflagration will be the consequence.

DCXLVIII.

PERCUSSION CAUSES THE DETONATION OF PHOSPHORUS WITH IODATE OF POTASS.

Cut 3 grains of Phosphorus very fine, and mix with it 6 grains of Iodate of Potass; wrap them up hastily in a piece of paper, place them on an anvil, and strike them smartly with a hammer; violent detonation will be the consequence.

DCXLIX.

PREPARATION OF IODIDE OF AZOTE.

Into distilled Water fully saturated with Ammoniacal Gas, put some Iodine, as long as a dark powder falls down: pour off the liquor gently—(this liquor is a solution of Hydriodic Acid, and may be preserved for experiment)—and preserve the powder: this powder is the Iodide of Azote; the other portion of the Iodine having combined with the Hydrogen of the Ammonia forming Hydriodic Acid. This powder will detonate by the least heat or friction.

DCL.

IODIDE OF AZOTE EXPLODES BY FRICTION OR PERCUSSION.

Lay half a grain, or a grain of this powder gently on a tile, or an anvil, and rub it with a stick; or strike it with a hammer: in either case it will explode with very great violence. The same phenomenon takes place when this most explosive compound is slightly heated.

DCLI.

PREPARATION OF A WHITE DETONATING POWDER, BY THE DECOMPOSITION OF AMMONIA, BY MEANS OF CHLORIODIC ACID.

Agitate some liquid Chloriodic Acid in a phial containing Chlorine Gas: as the absorption proceeds, the liquid will be rendered colourless. If this colourless liquid be poured into pure liquid Ammonia, a white powder will be precipitated, which detonates by the gentlest heat or friction.

DCLII.

PREPARATION OF DETONATING SILVER.

Put 10 grains of pure Silver into a Florence flask, and pour over it half an ounce of strong Nitric Acid, with half an ounce of distilled Water; when nearly dissolved, put it over a lamp, and then pour in half an ounce of Alcohol; when it has received considerable heat, a white heavy powder will fall to the bottom. When this precipitation ceases, agitate the whole gently, and pour it on a filter;

wash out any residuum with warm water, and pour this also on the filter; continue to pour distilled water over the powder until it runs through quite tasteless. Now dry the powder in a watch-glass or wide-mouthed phial by a gentle heat; and when any is wanted for experiment, take it out with a small wooden spatula.

Observation. A larger quantity than what is here directed, should not be made at one time, for fear of accident.

DCLIII.

DETONATING SILVER EXPLODES BY PRESSURE.

Wrap a grain of Detonating Silver in a small piece of paper, place it on the floor, and press upon it with the heel; a brisk explosion, with slight inflammation, will be the consequence. The same will take place, when this substance is struck upon an anvil.

Observation. This compound has been made the subject of many amusing experiments, by inclosing small quantities of it in glass beads, &c. and pasting paper over them; they are then called *detonating balls.* There are also *detonating spiders, detonating letters,* &c. &c. &c.

DCLIV.

DETONATING SILVER EXPLODES BY CONTACT WITH NITRIC ACID.

Throw 2 grains of Detonating Silver into a gallipot, containing 1 dram of Nitric Acid; explosion and inflammation will take place, and the Acid will be thrown about.

DCLV.

DETONATING SILVER EXPLODES BY CONTACT WITH SULPHURIC ACID.

Place a grain or two of Detonating Silver on a tile or marble slab, and touch it with a straw which has been immersed in Sulphuric Acid; explosion and inflammation will be the consequence. If a dram of Sulphuric Acid be poured into a gallipot, and a grain or two of this powder be thrown in, it will display the same phenomena, but with greater risk to the operator's clothes, as the Acid will be scattered about.

DCLVI.

PREPARATION OF FULMINATING SILVER.

Prepare a solution of Nitrate of Silver, and pour into it a solution of pure Lime in water, as long as a precipitate will fall down. Filter the liquid, and wash the precipitate by pouring warm water on it, as it stands on the filter. Now put the powder into a warm place upon paper, that it may be well dried; then put it into a wide-mouthed phial, containing pure liquid Ammonia; cork it, and let it remain undisturbed for a whole day, or until the powder becomes black. Now pour off the supernatant liquor, and put the phial, open, in a place where the heat may not be more than 80° or 100°. When dry, this powder is very explosive, and should remain undisturbed in the phial where the process was finished; as sometimes, the least friction will cause an explosion of the whole mass. The lid of a pill-box is the best cover the phial can have, as frequently in taking the powder out, a part adheres to the neck; and then if a stopper or cork be put in, the friction occasioned even by this, is sometimes sufficient to explode the whole. Perhaps, if all Fulminating powders were dried in watch-glasses, and permitted to remain in them till wanted for use, it would be much safer.

DCLVII.

FULMINATING SILVER DETONATES WHEN HEATED.

Take (out of the phial where it has previously been prepared) 2 grains of Fulminating Silver on the point of a small wooden spatula, and place it on a clean fire-shovel; place the shovel over the fire for a few seconds; a tremendous explosion, with an emission of light, will take place.

DCLVIII.

FULMINATING SILVER DETONATES (EVEN IN A MOIST STATE) WHEN FRICTION IS USED.

Put a grain or two of Fulminating Silver, whilst in a moist state, or newly prepared, on a table or stone; use friction as before; violent detonation will be the consequence.

DCLIX.

To prepare Fulminating Gold.

Prepare a solution of Gold in Nitro-Muriatic Acid, and pour it into a tumbler or ale-glass. Into this solution pour pure liquid Ammonia, as long as a precipitate falls down; but the instant in which the precipitate begins to disappear, (which will be by *re-solution* by means of the Alkali) desist. Now filter the liquid; and when the solution of Muriate of Ammonia has passed through, pour some warm water on the powder, in order to wash it well. When this water has also passed through, dry the precipitate, by merely laying the paper on which it lies, on the table, or in a window; because, if dried near the fire, it may explode. Take care also that no person, or thing may touch this powder, as the least friction will cause an explosion of the whole.

DCLX.

Fulminating Gold explodes by Friction.

Place a grain of Fulminating Gold on a table, plate of iron, or any other hard place; and rub a poker or hard stick upon it at arm's length: a loud explosion will take place.

DCLXI.

Fulminating Gold explodes when heated.

Put about a grain of Fulminating Gold on the end of a table-knife, and hold it over a candle; an immediate, and very loud explosion will take place.

DCLXII.

If three or four grains of Fulminating Gold are put on a plate of Copper, and if this plate be, by the aid of a pair of tongs, placed over a clear fire; in a few seconds a very tremendous report, accompanied by a flash of light, will take place. When the Copper is taken from the fire (if a thick plate), it will be found to be indented, as if struck by a hard body; but if it be a thin plate, it will be completely perforated.

DCLXIII.

PREPARATION OF FULMINATING COPPER.

Dissolve some pure Copper in diluted Nitric Acid, and pour into it some liquid Ammonia as long as a precipitate falls down. Pour the solution into an evaporating dish, and expose it to a temperature of 200° until the precipitate is merely in a moist state. Now place the dish in a lower temperature, until the powder is quite dry. This powder is known by the name of Fulminating Copper. Preserve it in a wide-mouthed phial, loosely covered with paper.

DCLXIV.

FULMINATING COPPER EXPLODES BY FRICTION.

Put a grain of Fulminating Copper on a hearth-stone, and rub it with the end of a poker; a loud explosion will be the consequence.

DCLXV.

FULMINATING COPPER EXPLODES WHEN HEATED.

Put 2 grains of Fulminating Copper on a clean fire-shovel, and hold it over the fire; in a few seconds it will explode with great violence.

DCLXVI.

TO PREPARE FULMINATING PLATINUM.

Prepare a solution of Nitro-Muriate of Platinum, and pour into it liquid Ammonia, as long as a precipitate falls down. Filter the liquid, and pour water over the powder on the filter in order to wash it. Put this powder into a small vessel, with a solution of pure Potass; and give it a boiling heat, until all the water has evaporated. Pour several waters over the residuum in order to wash it well; when the fluid that comes off, is tasteless, put the remaining powder on paper, and dry it by a heat not exceeding 200°. The Fulminating Platinum thus obtained is of a brownish colour. Too much should not be prepared at one time; and it should be preserved in the same way as the Fulminating Gold.

DCLXVII.

FULMINATING PLATINUM EXPLODES WHEN HEATED.

Put 2 grains of Fulminating Platinum on a plate of Copper just placed over a clear fire; when the temperature is raised to a little more than 400°, the powder will explode with great violence, and the Copper plate, if thin, will be perforated; if a thick one, it will only be indented: the principal force of this powder, like that of Fulminating Gold, being exerted downwards.

DCLXVIII.

TO MAKE FULMINATING MERCURY.

Put 50 grains of Mercury into a retort, and pour over it 6 drams of strong Nitric Acid; place the retort over a lamp until the Metal is dissolved. Now pour an ounce of Alcohol into a Florence flask, and when the Nitrate is cold, pour it in also. Place the flask on the ring, at a considerable distance above the flame of the lamp, so as not to heat it too much at first; effervescence will soon commence, and a powder will be precipitated immediately after. When the whole of the precipitate has fallen down, pour the contents of the flask on a filter, wash out the precipitate with water, and pour this also on the filter. When the liquor has passed through, pour distilled water over the powder, in order that it may be totally freed from the acid: this will be known by the water passing through quite tasteless. Collect the powder on a watch-glass, and dry it in a place, the temperature of which does not exceed 100°. This Fulminating Powder will weigh about a dram, and may be preserved either in a watch-glass, or in a wide-mouthed phial.

DCLXIX.

FULMINATING MERCURY DETONATES BY PERCUSSION.

Place a grain of Fulminating Mercury on a marble slab, and rub it by applying the end of a stick; a loud detonation, with vivid inflammation in the dark, will be the result.

DCLXX.

FULMINATING MERCURY EXPLODES WHEN HEATED.

Place two or three grains of Fulminating Mercury on a plate of Copper, or on a fire-shovel; hold it over the fire for a few seconds, a very loud explosion will ensue.

CHAPTER XIV.

ON THE EVOLUTION AND ABSORPTION OF HEAT

EVOLUTION OF HEAT.

The following Experiments shew that Heat and Light may be elicited by Friction and Percussion.

DCLXXI.

Heat produced by the Percussion of Iron.

If an Iron rod be repeatedly hammered on an anvil, and the Percussion be smartly kept up; it will at last become red hot.

Observations. On examination, the iron will be found condensed in bulk; its particles having been forced into closer contact. The experiment cannot be repeated with the same rod, unless it be previously put into the fire, and then allowed to cool.

DCLXXII.

Heat produced by the Friction of Wood.

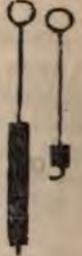
If two pieces of dry wood are rubbed against each other very smartly for a considerable time, they will turn hot, and emit smoke. Soon after, if the rubbing be kept up with energy, they will take fire.

Observations. In this way, many tribes of American Indians kindle their fires when they are on hunting and fishing expeditions. Mills and cart-wheels, when not properly anointed, catch fire by the friction of one part upon another. Forests, even, are said to have been set on fire, by the friction of trees against each other.

DCLXXIII.

Heat elicited by Compression *Of Atmospheric Air.*

Put a piece of tinder on the end of the piston of a small brass cylinder, which shall be air-tight; press down the piston, with a smart blow, and the tinder upon examination will be found to be on fire. The figure of an apparatus for this purpose, for domestic convenience, is annexed. There is a sharp steel pin at the bottom of the cylinder to prevent it from slipping, when forced against a table, &c. when light is to be produced.



Observations. The heat is extricated by the sudden compression of the air in the cylinder, which is reduced from a great volume to one of a smaller extent; and the combustion is assisted by the oxygen of the air, which, though diminished in volume, is the same in quantity as before compression.

OBSERVATIONS ON THE PNEUMATIC TINDER-BOX.

The instrument above mentioned is of French invention, and it is said that the principle of its action was discovered during the revolutionary war, by a soldier, whilst charging his air gun. It is now much used as a means of procuring instantaneous light. The matches employed are generally pieces of Agaric, (one of the species of fungus called Boletus,) boiled and dried, and afterwards slightly impregnated with nitrate of potass, (salt-petre) in solution. They are afterwards gently but completely dried.

The promoter of this discovery, M. Le Bourier Desmortiers, having performed a variety of Experiments with this instrument, relates in the Journal de Physique, the several results. A few extracts from the paper in question may not be unacceptable.

" The inflammation of spunk in the pneumatic tinder-box, by the compression of air alone, is a phenomenon with which chance, the father of discovery, has lately enriched natural philosophy. Many have reasoned on its cause; which some consider to be caloric, others electricity; but no one, that I know of, has attempted to support his opinion by experiments.

" The goodness of the instrument does not depend on the length of the piston, but on the accuracy with which it fills the bore of the tube.

" It is essential too, that the instrument does not leak at the part where the spunk is placed; because there, the transient action of inflammation takes place, and a slight emission of air would prevent the effect: but this effect is produced, though the piston does suffer the air in the tube to pass it. To satisfy myself of this, I made the following experiment, at which they who have seen it were greatly surprised.

" In the length of the piston I made a groove, a quarter of a line broad. The spunk took fire as before. Three other grooves were added successively opposite to each other, so as to divide the piston into four equal parts; and still the spunk took fire. When the grooved piston is moved backwards and forwards in the tube, the air may be heard entering or issuing out; and the friction is so slight, that the effect of the instrument is easily obtained by pushing it with the hand.

" The piston with four grooves acting very well, I made one with a single groove, of dimensions equal to the other four, and what I foresaw, actually took place: there was no inflammation.

"When a glass instrument is made to act, and the spunk kindles, we see a bright flash, which fills the capacity of the tube; and this light is so much the more vivid, in proportion as the compression is more rapid. If the compression be less powerful the spunk does not kindle; but we perceive in the upper part of the tube a light vapour, that falls in undulations on the piston. When this has disappeared, if we draw back the piston, the vapour will re-appear, as long as there is any air in the tube. These effects may be produced several times in succession, merely by pushing the piston with the hand. This vapour is so thin and diaphanous, that it is not perceptible in a strong light. It requires a sort of twilight to see it well.

"I substituted hydrogen for common air, and the vapour showed itself as before; but the spunk did not take fire. With carbonic acid gas, and with nitrogen, the effects were the same. The latter, which contained a little nitrous gas, gave a somewhat denser vapour. Oxygen, lightly compressed, yielded a vapour more rare and transient than that from common air. It had scarcely fallen on the piston when it rebounded and disappeared. When I compressed oxygen with a proper force for producing inflammation, the spunk, which commonly takes fire only at the anterior part, was almost entirely burned: yet for this experiment I used a copper instrument, the piston of which lost air so much, that it would no longer kindle spunk, with common air.

"Perhaps it will be said, that the vapour came from the greasy matter on the piston, which adheres to the sides of the tube; and that it is expanded by the heat produced by the friction. To this I answer, in this case, 1st. The vapour should not shew itself before the greasy matter is deposited on the sides of the tube; yet it appears at the first stroke of the piston, before the tube becomes greasy. 2dly. It should show itself below the piston, in the part which the piston has left; but, on the contrary, it always shews above. 3dly. There is no vapour, when the piston loses much air, if the friction be ever so rapid. 4thly. The vapour should be more apparent, when the piston exerts its friction throughout the whole length of the tube, than when it is confined to a small part of its upper extremity; yet the reverse frequently happens. 5thly. When the air is entirely decomposed, no more vapour appears, but it shows itself again, if ever so little fresh air be introduced.

"As it was essential to ascertain whether the vapour did not contain an acid principle, I fastened to the surface of the piston, with a little green wax, a piece of muslin dipped in infusion of litmus, and afterwards dried. After twenty strokes of the piston the colour was not changed. I put on a second piece of muslin larger than the first, and the edges of which were loose. This was burned all round, without the colour of the rest being altered. Lastly, a third piece which was wet, experienced no change of colour.

"From these experiments it follows, that no acid principle is developed; that all aeriform substances, as well as common air, produce a light vapour; that no other gas, except oxygen and common air, kindles the spunk; that oxygen produces a much more powerful combustion than common air, consequently oxygen acts an important part in the inflammation; that as it can exert its action only when set free by the decomposition of the common air, of which it constitutes a fourth part, it follows, that the air contained in the tube is decomposed by the simple force of compression; that the vapour produced is not owing to the oxygen, since it shows itself equally in gases that contain no oxygen;

that this vapour is the effect of some agent common to all gases; and that we may presume it is caloric itself, rendered visible by the sudden approximation of its parts in a small space, where it rises to a temperature that is increased in the oxygen so as to kindle the spunk.

"It sometimes happens that the spunk is turned black without kindling. In this case, as well as when it is kindled, if we draw back the piston in the tube, a dense vapour that may be smelt, issues out, which is not of the same nature as the former. That shows itself before the inflammation: this always succeeds it. That is the principle of the inflammation: this is a product furnished by the combustion of the spunk, of which it has the smell."

A very important experiment has recently been made by M. Biot. It consists in breaking, by means of a suitable apparatus, a ball of glass filled with oxygen gas, and placed in the receiver of an air-pump, in which as perfect a vacuum as possible has been formed. The effect is to produce, in a dark room, a very brilliant light, as a consequence of the rapid expansive motion of the oxygen.

DCLXXIV.

LIGHT PRODUCED BY THE PERCUSSION OF QUARTZ STONES.

If two Quartz Stones are struck against each other, they will emit light: if they are struck under water, the same effect will take place.

DCLXXV.

LIGHT PRODUCED BY THE PERCUSSION OF SUGAR.

If two pieces of Loaf-sugar (about a pound each) are struck against each other in a dark place, a light-blue flame, like lightning, will be elicited. The same effect takes place when a loaf of sugar is struck with an iron instrument.

DCLXXVI.

FIRE PRODUCED BY THE COLLISION OF IRON, *and Sulphuret of Iron, (Pyrites.)*

Instead of a Flint, fasten a piece of Pyrites in a gun-lock, and fill the pan with gunpowder: when the trigger is drawn, sparks of fire will be produced, which will inflame the gunpowder. This substance gives out white and red sparks when used without gunpowder.

Observations. Mr. Wedgewood found that the luminous particles disengaged by holding a piece of common window-glass to a revolving grindstone, possess heat sufficient to inflame gunpowder.

DCLXXVII.

COMPRESSION CAUSES THE COMBUSTION OF PHOSPHORUS.

Take a small piece of Phosphorus, of the size of a pea, put it on a deal board, and press a piece of wood or other substance over it with considerable force: inflammation will be the consequence. If a piece of Phosphorus of the same size be held in a forceps, and rubbed against the rough surface of a sheet of brown paper, it will not only inflame immediately itself, but will also set fire to the paper.

DCLXXVIII.

COMPRESSION CAUSES THE COMBUSTION OF *Potassium with Phosphorus.*

Cut a small piece of Phosphorus of the size of a split-pea; place near it on a marble slab, a small globule of Potassium. Press heavily with the end of a table knife on the two substances together; vivid combustion will take place, and the two substances will unite, forming, (by the assistance of Oxygen from the Atmosphere) Phosphate of Potass.

DCLXXIX.

COMPRESSION CAUSES THE COMBUSTION OF *Sodium with Phosphorus.*

Repeat the Experiment, but instead of Potassium, use Sodium; the pressure must be heavier. Combustion will be the consequence, and Phosphate of Soda will be the product.

DCLXXX.

PERCUSSION CAUSES THE DETONATION OF *Sulphur with Chlorate of Silver.*

Mix together four grains of Chlorate of Silver and two grains of Sulphur, in a piece of paper, and strike it lightly upon an anvil. A most violent detonation will take place, accompanied with a white flame, similar to a flash of lightning.

Observation. Upon examination, the silver will be found in the metallic state.

DCLXXXI.

PERCUSSION CAUSES THE COMBUSTION AND DETONATION *Of Chlorate of Potass with Sulphuret of Antimony.*

Mix together three grains of Chlorate of Potass, and five grains of Sulphuret of Antimony, and put them on an anvil. A smart blow upon these substances with a hammer will cause a vivid flash, and a very loud report.

DCLXXXII.

INFLAMMATION OF PHOSPHORUS WITH SULPHUR BY *Friction: or, Preparation of the Phosphoric Fire-bottle.*

The Fire-bottle is founded on the known property of Phosphorus to inflame more or less rapidly, according to the nature and state of the substances upon which it is rubbed.

It is on this principle that all the Phosphoric Fire-bottles are made. The most simple of these, of which the following is a description, is recommended by the French Society for the Encouragement of Inventions, &c.

The substances that most easily effect this inflammation may be classed in the following order: 1st, the felted hair of animals, in proportion to their degree of fineness: 2nd, the interior surface of animal skins when dressed and prepared, such as leather gloves: 3rd, woollen cloths, silk stuffs, cotton, and rough thread that is worn (that which is smooth and dressed is of no use): 4th, cork, light coal, and in general all animal and vegetable substances, and even minerals, such as the asbestos, which are rough and elastic: all hard and smooth bodies, such as wood, parchment, varnished skins, and metals, are improper for this purpose. Phosphorus does not inflame upon these bodies except when, by friction, either they or the Phosphorus are brought to a temperature approaching to that at which the Phosphorus inflames by contact with the air.

The preparation of these Fire-bottles is extremely simple. About eighteen or twenty grains of Phosphorus are to be put into a phial, or glass-tube, of any length, so that it can be easily held in the hand. The lower part of this tube may be filled with any substance whatever, which is to be pressed down with a cork. A space being reserved for the Phosphorus, it is cut into small pieces and put into the bottle, which is immediately stopped with a good stopper. By heating with precaution, at a lamp, the part which contains the Phosphorus, this substance quickly melts, and falls to the shape of the bottle as it cools; the Fire-bottle is then completed. The manner of using it is equally simple: the little bed of Phosphorus is lightly scratched with a common match, a very small portion adheres to the match, and on being afterwards lightly rubbed upon any of the substances before-mentioned, as are proper to inflame it speedily; or even upon the stopper, it takes fire more or less rapidly, and communicates inflammation to the match.

A hundred matches in succession may be lighted either upon a piece of felt, or on the inside of a skin glove, without consuming more than a grain and a quarter of Phosphorus.

Observation. These fire-bottles are not so dangerous as the old ones, which inflame by the simple contact of the air, and with a rapidity which has always something terrifying in it. They are, besides, free from the disadvantage to which the old fire-boxes and the oxygenated matches are subject, of causing burns and stains, either from the phosphoric acid which is often detached by the combustion; or from the sulphuric acid into which the oxygenated matches are dipped; and which too frequently fall upon some part of the surrounding bodies.

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When bodies are mixed or combined, and the density or bulk becomes less than that of the fluids before mixture, Heat will be evolved.

DCLXXXIII.

HEAT PRODUCED BY THE MIXTURE OF *Nitric Acid with Water.*

Into a phial containing half an ounce of Nitric Acid, pour two drams of Water; and plunge a Thermometer into the mixture;—the Mercury will rise to 112°, and very sensible heat will be felt by the hand. The *Condensation* of the two fluids; (that is, the specific gravity of the mixture being greater than the mean specific gravity of the fluids employed,) is the cause of so much heat being given out.

DCLXXXIV.

INTENSE HEAT CAUSED BY THE MIXTURE OF *Sulphuric Acid with Water.*

If three ounces of Sulphuric Acid are put into a tall beer-glass, and one ounce of Water be added; the mixture will evolve so much heat, that a thin glass-tube filled with cold Water and immersed in the Beer-glass, will actually *boil*: at the same time, if a Thermometer is immersed in it, the temperature will be found to be 300°, that is 88 degrees above the boiling point, 212°. The mixture may now be seen to have decreased considerably in bulk, from what the Sulphuric Acid and Water were, singly.

Observations. Here, we have the evolution of great heat, without light or flame. In order that the liquids may intimately combine, the sulphuric acid parts with its latent caloric, and consequently decreases in bulk.—Economy forbids that the new-formed mixture should be thrown away, as it may be kept for the performance of other experiments.

DCLXXXV.

INTENSE HEAT PRODUCED BY MIXTURE OF *Fluoric Acid with Water.*

Place a tea-cup or gallipot, containing an ounce of Water, on the hearth, and pour into it, (at arm's length, the hand being defended by a glove), half an ounce of Fluoric Acid from a leaden-bottle. Sudden ebullition and most intense heat will be the consequence.

Observations. It is not advisable to touch the gallipot, as this acid is most corrosive, producing ulcers on the skin wherever it touches: if such an accident should unfortunately happen, with this or any other acid; the best, and indeed the only remedy, is, immediately to plunge the part into a vessel of cold water.

Another precaution too, is necessary, with regard to this experiment: that is, to perform it, if possible, in the open air; as the dense fumes arising from it, are highly corrosive,—particularly, when they attack the internal surface of the nose.

DCLXXXVI.

GREAT HEAT RESULTS FROM THE MIXTURE OF *Ice and Sulphuric Acid.*

If an ounce of Sulphuric Acid, of the temperature of 32°, be poured over an ounce of pounded Ice, of a like temperature; the density of the combined substances will be greater than that of the two substances separately; and in this condensation, so much latent Caloric will be evolved, that the mixture will give out heat, equal almost to that of boiling Water. If the hand, or a Thermometer, be applied to the glass, it will receive in a sensible form, what before existed only in a latent state, in a cold fluid.

Observation. The other strong acids produce like effects, when mixed, in certain proportions, with water, ice, &c.

DCLXXXVII.

THE DECOMPOSITION OF SULPHURIC ACID, BY LIME, *Is attended by Combustion.*

If some pure Lime be put into a tea-cup, and strong Sulphuric Acid be poured over it, the heat evolved will be so great, as even to make some of the Acid volatile. This extrication of Caloric, is owing to the sudden transformation of a solid and liquid, into a solid substance. If the experiment be performed in a dark room, light will be observed to be extricated.

DCLXXXVIII.

ACTION OF OXYGENATED WATER ON OXIDE OF SILVER.

When a drop of Oxygenated Water is let fall upon a stratum of Oxide of Silver, placed at the bottom of a glass, detonation takes place: the Oxygen of the Water, and that of the Oxide, being disengaged; a great quantity of heat is developed; and light is produced so sensibly, as to be perceived where the darkness is not very intense.

Observation. The same phenomena take place with silver, platinum, gold, osmium, iridium, rhodium, the peroxide of cobalt, &c.

Oxygenated water, for every 100 parts contains 88 of oxygen.

DCLXXXIX.

WATER SOLIDIFIED, BY MIXTURE WITH *Sulphate of Lime, (Plaster of Paris.)*

Put some powdered, calcined Sulphate of Lime into a basin, and pour over it as much Water as will make it into a thin dough: mould this quickly into any shape. Almost, before the moulding is complete, the whole mass will be so hardened, that it will require a heavy blow of a hammer to break it, or reduce it again to powder. Here, the Water is chemically combined with the salt.

Observations. In preparing casts, moulds, &c., the plaster of Paris always gives out heat when it begins to *set*, or harden. This may be perceived by laying the hand on it at the time, when it will feel warm. Modellers say, that, when taking casts of any part of the human body, this is the instant when the plaster should be removed; as whenever the cast becomes hardened, the *contraction,* or *condensation of bulk* is so great, as to cause most acute pain in the part under the operation.

For the manufacture of stereotype plates, plaster of Paris, (of the consistence of a batter-pudding before baking) is poured over the letter-press page, and worked into the interstices of the types with a brush. It is then collected from the sides by a slip of iron or wood, so as to lie smooth and compact. In about two minutes, the whole mass is hardened into a solid cake. This cake, which is to serve as the matrix of the stereotype plate, is now put upon a rack in an oven, where it undergoes great heat, so as to drive off superfluous moisture. When ready for use, these moulds, according to their size, are placed in flat cast-iron pots, and are covered over by another piece of cast-iron perforated at each end, to admit the metallic composition intended for the preparation of the stereotype plates. The flat cast-iron pots are now fastened in a crane, which carries them steadily to the metallic-bath, or melting-pot, where they are immersed and kept for a considerable time, until all the pores and crevices of the mould are completely, and accurately filled. When this has taken place, the pots are elevated from the bath by working the crane, and are placed over a water trough, to cool gradually. When cold, the whole is turned out of the pots, and the plaster being separated, by hammering and washing, the plates are ready for use; having received the most exact and perfect impression.

DCXC.

WATER SOLIDIFIED WHEN COMBINED WITH PURE LIME.

If a piece of quick Lime be immersed in a basin of cold Water, it will absorb a great quantity of it. The heat evolved by this union will be so great, that the hand can scarcely endure it. If taken out of the water it will appear almost dry, but increased in bulk. It will also smoke: this is caused by evaporation of some of the water from the surface, and by the intense heat produced, in the act of combination. Ships carrying Lime have often been burnt, from the penetration of Water into their cargo.

To vary this Experiment, pour some water on a piece of pure Lime, (in a basin,) in a dark room: if observed attentively, this combination will be seen to cause an extrication of light.

Observation. Whether this luminous appearance be owing to any property in the lime itself, or to the sudden solidification of the water and combustion of part of its hydrogen, is not known.

DCXCI.

HEAT EVOLVED WHEN MURIATIC ACID GAS *Combines with Ammoniacal Gas.*

When Muriatic Acid Gas and Ammoniacal Gas are brought into contact, they combine forming a solid substance,—the Muriate of Ammonia. In this combination heat is evolved, which may be known by holding a Thermometer in the jar where the gases are combined.

Observation. There is an apparatus exhibited in plate 19, for shewing the evolution of latent heat, by gases or vapour, in the act of conversion into a liquid state. The apparatus is simple, and will easily be understood. Thermometers are placed in each vessel to shew the difference of the actual heat of the Gas, and the latent heat, which escapes on condensation.

DCXCII.

HEAT EVOLVED WHEN OXYGEN, AND NITROUS *Gases combine.*

When Oxygen and Nitrous Gases are combined, they form a liquid,—Nitric Acid. In this combination, Caloric is evolved. They should be mixed over Mercury.

DCXCIII.

SOLUTIONS OF MURIATE OF LIME, AND PHOSPHATE *Of Soda, solidified by Mixture.*

Pour six drams of a solution of Muriate of Lime into a glass containing an ounce of a solution of Phosphate of Soda. These Salts will mutually decompose each other, and so large a quantity of Phosphate of Lime will be precipitated, that a great portion of the mixture will appear in a gelatinous mass.

Observation. These solutions should be saturated;—that is, no more water should be used to dissolve the salts, than is barely necessary for that purpose, in a cold state.

DCXCIV.

SULPHURIC ACID, AND MURIATE OF LIME IN SOLUTION, *Become solid, by Mixture.*

Into a phial containing about two drams of Muriate of Lime, pour as much Water as will just dissolve that Salt; now pour in a few drops of Sulphuric Acid; the contents of the phial will immediately become solid. Here the Sulphuric Acid combines with the Lime, forming Sulphate of Lime, which being a very insoluble salt, is precipitated. During this solidification, considerable heat will be given out.

DCXCV.

CARBONATE OF POTASS, AND MURIATE OF LIME *In Solution, become solid by Mixture.*

Let four drams of Water in a wine-glass dissolve as much Carbonate of Potass as it can take up. Let the same quantity of Water, in another glass, dissolve as much Muriate of Lime as will saturate it also, and pour the contents of one glass into the other. When the mixture is stirred by a glass rod or tea-spoon, it will be instantly converted into a solid mass resembling the white of an egg when boiled.

Observation. Here a mutual decomposition takes place, for the muriatic acid, leaving the lime, attacks the potass, whilst the carbonic acid seizes upon the lime. In the solidification of the water which held them in solution, a quantity of latent heat is disengaged.

DCXCVI.

SOLUTIONS OF PURE POTASS, AND SULPHATE OF MAGNESIA *Solidified by Mixture*

A saturated Solution of Pure Potass, poured into an equal quantity of Sulphate of Magnesia, also saturated with Water; will exhibit similar phenomena to those resulting from the foregoing substances.

Observations. Here the sulphuric acid leaves the magnesia to unite with the potass, and heat is evolved.

The two last mentioned mixtures, may be liquified by adding nitric acid.

* * *

The following Experiments exhibit the phenomena which occur at the instant in which metals combine with other substances, and with each other. On these occasions they suddenly enter into combustion, and, sometimes, even deflagrate.

Deflagration is the sudden Combustion and Explosion of substances when they come in contact with an inflamed, or red-hot body.

DCXCVII.

DEFLAGRATION OF COPPER AND SULPHUR

When fused together.

If one ounce of Copper-filings be melted with three drams of Sulphur, the mixture suddenly explodes, and becomes red-hot, as the two substances unite. If taken from the fire in this state, it continues for a considerable time to shine vividly, and with great beauty.

DCXCVIII.

SUDDEN COMBUSTION OF SULPHUR AND IRON-FILINGS.

Put into a crucible, 3 drams of Sulphur, and when it has fused, put in 9 drams of Iron-filings: presently the two bodies will unite, and appear to be both in a state of active Combustion: the compound is a Sulphuret of Iron. Sometimes, deflagration takes place at the moment of union.

DCXCIX.

DEFLAGRATION OF PLATINUM WITH TIN.

If about equal bulks of Platinum and Tin be heated to redness, in contact with each other; they will combine suddenly with great vehemence, and a very considerable extrication of light and heat, which will continue for some time after their removal from the fire. The experiment is easily made, by enveloping a little bit of Tin in Platinum foil, and heating it by a blow-pipe on Charcoal; a sort of explosion takes place at the moment they combine, and the alloy runs about, burning like ignited Antimony.

Observations. If the melted globule be permitted to fall into a bason of water, it will for some time remain red-hot at the bottom. So intense is the heat, that the glazing of the bason will be carried off wherever it falls, even although it has passed through so cold a medium as the water.

DCC.

PLATINUM WITH ANTIMONY.

When Platinum and Antimony are heated together in the same manner, a similar effect will take place.

This alloy, when highly heated for a considerable time, becomes solid, and very malleable, containing little else than Platinum.

DCCI.

PLATINUM WITH ZINC.

When Zinc and Platinum are similarly heated, the combustion will be very brilliant; as the Alloy will explode with much splendour and burn at the instant of combination.

Observation. Other metals exhibit similar phenomena when heated with platinum.

DCCII.

VIOLENT COMBUSTION OF POTASSIUM WITH SULPHUR.

If a small quantity of Sulphur and Potassium be heated together in a crucible, they will soon unite, with violent Combustion, forming Sulphuret of Potassium.

DCCIII.

SUDDEN COMBUSTION OF POTASSIUM WITH TIN.

When equal parts of Tin and Potassium are melted in a crucible, light will be evolved, at the instant of their union, as they form an Alloy.

DCCIV.

COMBUSTION TAKES PLACE WHEN ARSENIC IS *Heated with Potassium.*

Union, but with weaker Combustion, takes place, when Potassium and Arsenic are heated together. The Alloy is Arseniuret of Potassium.

The following experiments, which were performed by M. Thenard and M. Gay Lussac, exhibit the action of Potassium on various Salts containing Oxygen. In these cases, the Potassium displays a greater affinity for Oxygen at a higher temperature than any of the other substances employed.

DCCV.

MURIATE OF SILVER.

Muriate of Silver having been fused, and heated to the point of ignition, was pulverized and introduced into a glass tube, into which previously had been introduced a bullet of Potassium. The tube was now heated at a lamp: scarcely did the degree of heat applied exceed what was necessary to fuse the metal, when very brilliant inflammation was excited, and the two Salts were in consequence reduced.

Observations. A similar experiment having been performed with muriate of mercury, the phenomena were the same.

In both reductions the tubes were fractured; and in that containing muriate of mercury there was a slight detonation, owing to the mercurial vapour.

In these and the following experiments, the heat was somewhat greater than what was necessary to fuse the metal. Sometimes, as for instance, with respect to the decomposition of phosphate of lime, sulphate of barytes, oxide of zinc, &c. it was carried to 300° of the centigrade thermometer. The tubes employed were always fractured during the inflammation, when it was most vivid.

DCCVI.

SULPHATE OF BARYTES.

When this Salt was heated with Potassium, there was a lively inflammation. Sulphuret of Barytes was formed · the Oxygen having combined with the Potassium.

Observations. Sulphite of barytes was decomposed without inflammation, and sulphuret of barytes was obtained.

It may be concluded from these two experiments that oxygen is much less condensed in the sulphite, than it is in the sulphate of barytes, and very probably less in the sulphurous, than in the sulphuric acid.

DCCVII.

SULPHATE OF LIME.

When Potassium was heated with Sulphate of Lime, there was a slight inflammation with the formation of a very yellow Sulphuret.

DCCVIII.

SULPHATE OF LEAD.

When Sulphate of Lead and Potassium were heated together, at the instant of decomposition, the inflammation was remarkably vivid.

DCCIX.

SULPHATE OF MERCURY.

Sulphate of Mercury which was in a slightly oxidised state, being employed, was decomposed with similar phenomena to those exhibited in the decomposition of the Muriates of Mercury and Silver.

DCCX.

NITRATE OF BARYTES.

A Globule of Potassium heated with this salt, will decompose it so suddenly, and with so much force as not only to cause vivid inflammation, but also a most violent projection of the materials out of the tube; and in some cases the destruction even of the tube itself.

DCCXI.

CHLORATE OF POTASS.

This salt is well known to be one of those employed for detonating purposes. When heated with Potassium, the inflammation was remarkably vivid, and the expansion so great as to break the tube.

Observation. The other chlorates (as that of lime, &c.) exhibited precisely the same phenomena.

DCCXII.

CHROMATE OF LEAD.

When Potassium and Chromate of Lead were heated together; a vivid flash announced the decomposition.

DCCXIII.

CHROMATE OF MERCURY.

On heating this beautiful salt with the Alkaline Metal, the inflammation was certainly not very vivid, but the red colour of the salt was instantly converted to *green*.

DCCXIV.

TUNGSTIC ACID.

This Acid, when heated with Potassium was decomposed with a very vivid inflammation.

DCCXV.

RED OXIDE OF MERCURY.

Potassium decomposed this substance with a very vivid inflammation. Detonation also took place, owing to the volatilization of the Mercury.

DCCXVI.

OXIDE OF TIN

This substance Oxidised at a Maximum, when heated with the Alkaline Metal, gave out a very bright flame, at the instant of decomposition.

Observation. Oxide of manganese exhibited similar results.

DCCXVII.

OXIDE OF BISMUTH.

When yellow Oxide of Bismuth gave up its Oxygen to the Potassium; the Inflammation was remarkably vivid.

Observations. The gray oxide of nickel also gave up its oxygen with vivid inflammation. The following are the phenomena which resulted from the employment of other substances; which though not so remarkable as the foregoing, are worthy of record.

Chromate of lead.—A very lively inflammation.
Arseniate of cobalt.—Lively inflammation.
Oxide of tin (putty.)—Flame not vivid.
Red oxide of iron.—Very slight inflammation
Oxide of silver.—Very lively flame.
Oxide of lead, gray.—Like the last.
Yellow oxide of lead.—Idem.
Yellow and brown oxides of copper.—Lively flame.
White oxide of arsenic—Flame.
Black oxide of cobalt —Idem.
Volatile oxide of antimony.—Flame, but less lively than with the oxides of copper.
Oxide of antimony at a maximum.—Lively flame.

DCCXVIII.

GREEN OXIDE OF CHROMIUM.

When this Oxide is heated with Potassium, there is no inflammation whatever, but a production of blackish matter, which being completely cooled, and afterwards exposed to the air, takes fire, like good Pyrophorus, and becomes yellow. This is a combination of Potass and the Oxide of Chromium, which changes, on exposure to the air, to Chromate of Potass.

Observations. In the following cases there was no inflammation; although the other phenomena exhibited, render them worthy of insertion in this place.

Nitrate of potass.—Destruction of the metal without inflammation, which is doubtless owing to the water contained in the nitre.

Phosphate of lime.—Decomposition, without any appearance of inflammation; the phosphate being converted to a phosphuret.

Carbonate of lime.—Decomposition without inflammation; naked carbon being detached.

Black oxide of iron.—No flame, but the oxide was reduced.

Oxide of manganese *at a maximum.*—No flame.

White oxide of zinc.—Reduction without flame.

Messieurs Thenard and Lussac observe, that they have also traced the effects of the metal obtained from the vegetable alkali, upon the earths, and particularly upon zircon, silex, yttria, and barytes; and found that it was very obviously altered by each; but as the cause of this alteration is but little known, they did not enter into any inquiry upon the subject; only that it is very probable that the phenomena observed in burning the metal of potass in silicated fluoric acid gas, depends in no respect upon the silex.

However this be, it follows, from all the preceding facts, that every substance in which we know oxygen to be present, are decomposable by the metal *potassium*; and that almost all such decompositions take place *with the disengagement of light and caloric*; also that the disengagement is proportionable to the degree of condensation of the oxygen in each body.

ABSORPTION OF HEAT.

DCCXIX.

LATENT HEAT IS NECESSARY TO PRESRVE BODIES *In the Solid, Liquid, and Gaseous States.*

If a Thermometer be fixed in a pan of Snow over a fire; it will, if higher than 32°, sink down to that point, and remain there until the Snow is completely converted into water. After the Snow has been melted, the Thermometer will rise in proportion as more heat is applied; and will continue to do so, until it arrives at 212° the boiling point.

Observation. Here the snow has been receiving a continual supply of heat from the fire: but this was necessary to change it into, and to preserve it in a liquid state. The heat which entered the water after being rendered fluid, may be termed *sensible* heat, because the thermometer indicates the different degrees of heat which the water may afterwards receive. The cause of the sinking of the Thermometer in the first instance to 32°, is, that it imparts to the snow the surplus of its own heat above 32°, to assist in melting it.

DCCXX.

CALORIC BECOMES LATENT IN BODIES,

When they change their Densities.

If any weight of Snow, or pulverized Ice at 32°, be mixed with an equal weight of water at 172° it would naturally be expected that the temperature of the mixture would be 102°, or one half. But this will not be the case; for if the Thermometer be applied, the temperature of the whole will be found to be only 32°.

Observation. It seems strange, that the snow or ice should have no addition of caloric, whilst the water has suffered an abstraction of 140 degrees! But it is evident, that the use to which the 140 degrees were applied, was to liquify the snow, without increasing its temperature. Therefore, water at 32°, requires 140 degrees of latent caloric to preserve it in a liquid state;—it cannot freeze until it has parted with that number of degrees; and on the other hand, ice cannot melt, until it has derived 140 degrees of latent heat from surrounding bodies.

DCCXXI.

If, when the temperature of the Air is at 22°, a Cyder-glass be half filled with spring-water, and a Thermometer be placed in it, (the top of the glass being covered,) the water will cool down gradually to 22°, without freezing. But if gently agitated, it will instantly freeze into a mass, similar to snow which is thawing; and the temperature will immediately rise to 32°, the freezing point:—thus, deriving the 10 degrees of Caloric, which were latent or concealed, from the previous fluid state of the water.

Observation. This quantity of caloric could not, before, have been indicated by the thermometer; consequently, it was latent, or, so combined with the particles of the water, as to seem to have changed its state. The same operation of latent caloric takes place in every other substance, such as metals, wax, tallow, &c.:—the first owe their ductility and malleability, and the last their softness and plasticity, to latent caloric.

DCCXXII.

LATENT CALORIC COMBINES WITH LIQUIDS

When they are converted into Vapour.

If water be heated to 400°, in a Papin's Digester, and the vessel be suddenly uncovered, one-fifth part will rush out, in the form of steam; and the temperature of the remaining water, will, at the same instant, sink down to 212°, (the boiling point,) losing no less than 188 degrees,—the difference between 400 and 212. These 188 degrees must have become latent, and must have combined with one fifth of the water to form the steam; for if the Thermometer, be applied to the steam, it also will be found to be only at 212°. Now, only one-fifth of the water was converted into steam; consequently, in addition to its own 188 degrees, it must have deprived the other four-fifths, each of their 188 degrees; and 188 multiplied by 5, produces 940, which is pretty near to 1000°;—the quantity of latent Caloric required to keep steam in its elastic form. Steam must part with an immense quantity of Heat, before it is condensed into water; and with much more, before it can be converted into Ice.

The following Experiments prove, that when Expansion of volume takes place during the combination of substances; Heat is absorbed from the surrounding atmosphere, or from any other body that comes in contact with the vessel containing the mixture. The body from which the heat has been absorbed is, of course, rendered cold.

Cold is the abstraction of Caloric from bodies, to a greater or less degree. This is indicated by the Thermometer. The abstraction of Caloric may vary from 32°, (the freezing point of Water,) to what is called the real Zero. In some countries Ice is absolutely unknown. When the Dutch told an Indian king, that at a certain season, in their country, Water was solid like Stone; and that men and horses could walk upon it, he supposed them to be impostors.

The *sensation of cold* implies the departure of Caloric from warm bodies, to cold ones; on the contrary, the *sensation of heat* implies the accession of heat to comparatively cold bodies from warm ones. Thus, the hand feels cold or warm, according as it comes in contact with cold or warm bodies:—in the first, Caloric quits the hand; in the second, it enters it.

It has been generally thought, that the most intense cold proceeds from snow; but there are other substances, which, when combined, produce still greater cold: these are, compositions of Salts with each other, or Salts with Snow and Ice.

DCCXXIII.

COLD CAUSED, BY THE SOLUTION OF *Muriate of Ammonia in Water.*

Pour 1 ounce of cold Water, upon 4 drams of Muriate of Ammonia, in powder, in a three or four ounce phial: cork it, and shake it well in the naked hand. As the Water and

Salt combine by this agitation, a very great degree of cold will be felt.

DCCXXIV.

LIQUEFACTION, AND THE SENSATION OF COLD,

Caused by the Combination of Ice with Sulphuric Acid.

Pulverize quickly in a mortar, 1 ounce of Ice, and pour over it in a tumbler, 1 dram of Sulphuric Acid, previously cooled to 32°. Stir the mixture, and the whole will become fluid. If a Thermometer be immersed, the temperature will be found very near 0°,—or 32 degrees below the freezing point. Here, the action of the Acid on the Ice, increases its volume, and, of course, much Caloric is absorbed from surrounding bodies, to be rendered latent, in the new compound. In the immersion of the Thermometer, 32 degrees of sensible Caloric are absorbed from the liquid contained in it; that is, from the Alcohol:—and if the hand be applied, very sensible cold will be felt, until the mixture has abstracted its full quantity of latent Caloric.

DCCXXV.

ICE LIQUEFIES RAPIDLY IN MURIATIC ACID GAS.

If a piece of Ice be put into a jar, containing Muriatic Acid Gas, it will liquefy with astonishing quickness, and if the hand be placed on the jar, very sensible cold will be felt from the rapid absorption of Caloric from the hand and surrounding bodies. This heat becomes latent in the liquefied Ice.

The Cold, produced by the following compounds, is so intense, that they have justly been denominated Freezing Mixtures.

DCCXXVI.

MURIATE OF AMMONIA AND NITRATE OF POTASS.

Pulverise 5 drams of Muriate of Ammonia and 5 drams of Nitrate of Potass; and add 2 ounces of water to them, in a Tin, Stoneware, or Glass vessel. If you plunge a Thermometer into the mixture, the Mercury will sink from +50°, to —10, that is 40 degrees; denoting the degree of cold produced. This mixture will freeze Oil of Turpentine, Wine, Water, Sea-water, Milk, and Vinegar.

Observation. In Plate 13, there is the figure of an apparatus for operating with freezing mixtures. The substances to be frozen are contained in the small vessels, whilst the freezing mixtures are put into the large one.

DCCXXVII.

SULPHATE OF SODA AND SULPHURIC ACID.

A mixture, of five drams of Sulphate of Soda, and four drams of diluted Sulphuric Acid, will lower the temperature of the Thermometer 47 degrees; that is, from +50°, to +3°. Sulphuric Acid, of various strengths, will freeze in this mixture.

DCCXXVIII.

NITRIC ACID WITH SEVERAL SALTS.

Mix together, six drams of Sulphate of Soda, four drams of Muriate of Ammonia, two drams of Nitrate of Potass, and four drams of diluted Nitric Acid. This mixture will lower the Thermometer from +50°, to —10°, which is 60 degrees.

DCCXXIX.

SNOW WITH NITRIC ACID.

Mix seven drams of Snow, with four drams of diluted Nitric Acid. If the Thermometer be at +32°; it will fall to —30°; being 62 degrees lower than the freezing point of Water. Sulphuric Ether may be frozen in this mixture.

DCCXXX.

SNOW AND MURIATE OF LIME.

Mix four drams of Snow, with five drams of Muriate of Lime: the Thermometer will sink from +32°, to—40°; being 72 degrees. This mixture will freeze Mercury.

DCCXXXI.

VARIATION, WITH SNOW AND MURIATE OF LIME.

Mix two drams of Snow, with three drams of Muriate of Lime: the Thermometer will sink from —15°, to —68°. This mixture will freeze Nitric Acid.

DCCXXXII.

SNOW AND SULPHURIC ACID.

Eight drams of Snow, mixed with ten drams of diluted Sulphuric Acid, will produce the greatest degree of cold known: that is, from —68°, to —91°; and is capable of freezing almost every known liquid, except Alcohol; which is said to require a freezing mixture, 110 degrees below Zero. The formula is not known. The degree of cold produced by the several mixtures in the three last Experiments, must be measured by a Thermometer containing Alcohol; as Mercury freezes, at —39°, and, of course, cannot indicate any lower degree.

Observations. Where the strong acids are used in freezing mixtures, glass vessels or gallipots will suit best; and the article to be frozen, may be in a Barometer-tube, or in a small phial.

The different substances here mentioned, may be used in larger quantities; but the operator must bear in mind, that any alteration in the above mentioned proportions, may materially impede the success of his experiments:—not, but that there may be proportions, yet undiscovered, which are capable of producing a greater degree of cold, than any here enumerated.

Where the salts are used, they must first be finely pulverised, and then mixed: as a previous minute division of the particles, assists most materially in producing the degree of cold required.

The cause of the cold, produced by these mixtures, is, the assumption of the liquid form. This change requires a proportional quantity of caloric, which is greedily absorbed from surrounding bodies. We should, therefore, quickly mix the ingredients; and immerse the article to be frozen, as speedly as possible, in order to take advantage of this great absorption. When the cold, required, is very great, (as in the three last Experiments,) the temperature of each of the ingredients, should previously be reduced by another freezing mixture of less power: for example; in the last experiment, the mixture must previously be cooled down to —68°:—unless this be first done, it cannot be reduced so low as —91°.

M. Gay-Lussac has proposed a method of producing cold, which may be extended, *ad infinitum;* but which suffers under the disadvantage of being applicable only to small masses of matter. All bodies change their temperature with their bulk, the former increasing if the latter is diminished, but diminishing if it is increased. If air be compressed to one-fifth its former volume, it will inflame tinder; and to do this it requires a heat more than sufficient to melt bismuth, or about 572° Fahrenheit. The air, therefore, has been thus heated by compression, into one-fifth of its former bulk; and we can easily suppose the possibility of raising it to 1000° or even much more, if it be strongly and rapidly compressed. If, therefore, a portion of air, compressed to one-fifth of its bulk, and reduced to the common temperature, be suffered to dilate instantaneously; it will absorb as much heat as it gave out on compression: and, supposing the capacity of the air to remain constant, will be reduced in temperature 572° Fahrenheit, &c. Taking air compressed by fifty, one hundred, or more atmospheres, the cold produced by instantaneous dilatation would have no limit.

CHAPTER XV.

EXPERIMENTS ON THE MOTION OF CALORIC. AND ON THE CAPACITIES OF BODIES FOR HEAT.

GENERAL OBSERVATIONS

THE supposed principle of Heat or Caloric has the property of Motion; for it continues to depart from heated bodies, and is absorbed by, or enters into, surrounding ones, until all are of an equal temperature.[*] This Motion is twofold; viz. by Reflection and by Radiation.

Reflection is that property of Heat and Light, by which, when their rays are thrown upon polished metallic surfaces,

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[*] As the generally received notions regarding the phenomena of Heat have been attacked with considerable force of argument by SIR RICHARD PHILLIPS, we shall here make the following extract from that writer's "SYNOPSIS of the PHILOSOPHY of MATERIAL PHENOMENA."

"When percussion or collision does not produce an equal quantity of aggregate motion in a proportionate change of place in the aggregate: or when the motion received cannot be transferred by diffusion, as when a piece of iron, laid on an anvil, receives the motion of a hammer; or when two pieces of wood are rubbed together, *an intestine re-action of the atoms in the iron and wood takes place, accompanied by the perception of heat, and by a series of phenomena depending on the quantity of motion thus concentrated, also on the acceleration of the same by repeated blows, rubbings, or transfers of motion.*

This intestine motion produces various phenomena of the several component atoms of the affected body in regard to one another, and to the heterogeneous media in which they are situated: thus, one quantity creates a perception of heat; another sensibly imparts that perception to the atoms of the surrounding media; another converts the fixed mass into fluids; an acceleration converts the fluids into diverging gas; and a farther acceleration, which exceeds the radiating powers of the surrounding media, decomposes those media; exhibiting flame and intense heat, in the solidification of the oxygenous part of the media, and, producing subtle radiations on the rare medium which fills space, thereby affecting the nerves of the eye with the perceptions of light.

The parting with each degree of atomic motion produces a contrary series of phenomena: thus gas, on parting with its heat or atomic motion to other bodies, becomes fluid; and fluids, by parting with their heat or excited motion, become solids; and the diffusion of heat or atomic motion on such re conversion is sensible, when the oxygenous part of atmospheric air, solidified by respiration, gives out what is called animal heat; and when the same, solidified by combustion, or reduced in volume by compression, gives out heat, and excites the pulsations of light."

they are immediately thrown back, or reflected. The angle of Reflection is always equal to the angle of Incidence.

Radiation consists in the progress of Calorific Rays, in straight lines, from heated or excited bodies.

DCCXXXIII.

POLISHED METALLIC SURFACES REFLECT HEAT.

Place two polished concave copper or tin Mirrors, with their concavities opposite to each other, in similar axes: put a pan of burning coals, or any other ignited body, in the focus of one of the mirrors, and a piece of touchwood in that of the other; the touchwood will almost instantly become ignited.

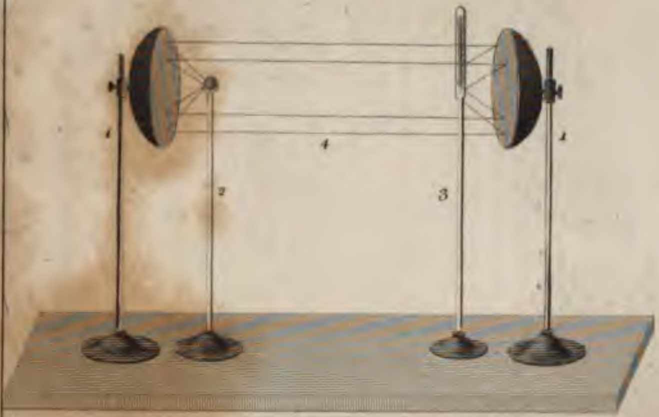
Observations. This fact can only be explained, in conformity with the prevalent doctrines of heat and ignition, by one or other of the following hypotheses:—either the caloric from the hot coals is communicated to the touchwood by the intermediate layers of air, or it darts in the form of rays from one mirror to the other, (See Plate 19.) and is thence reflected again to the focus, in which is the touchwood. The first of these hypotheses is inadmissible; for the rays which are nearer to the coals than the focus, are not so hot as the focus. We must, therefore, admit the second, which supposes the radiation of caloric.

The notion, that *cold* is capable of Reflection, is not correct. Professor Pictet placed two concave tin mirrors on stands, at the distance of ten feet and an half from each other; placing a Florence oil flask, filled with snow, in the focus of the one, and an air thermometer in that of the other. The thermometer sunk several degrees; but when the flask was removed, it rose to its original altitude. The experiment was repeated, and a greater degree of cold was produced by pouring either sulphuric or nitric acid, in a diluted state, into the flask. The snow was speedily melted, and became much colder than before. Accordingly, the thermometer fell several degrees lower, than when snow alone was used. When the flask containing this freezing mixture was removed, the thermometer rose, as at the first experiment.

This, however, is no proof of the emission of cold rays, from cold bodies. For, as caloric is known to radiate freely from all bodies, there is little doubt of its being absorbed by the freezing mixture from all bodies in the room; and from the thermometer among the rest. The interchange of heat, between the thermometer, and other bodies, was also thus stopped: because, it is well known, that a warm body always gives out its caloric to a neighbouring cold one, till they are both of the same temperature.

Thus, then, instead of the snow, and freezing mixture, emitting rays of cold, as at first might be supposed; the phenomenon of the

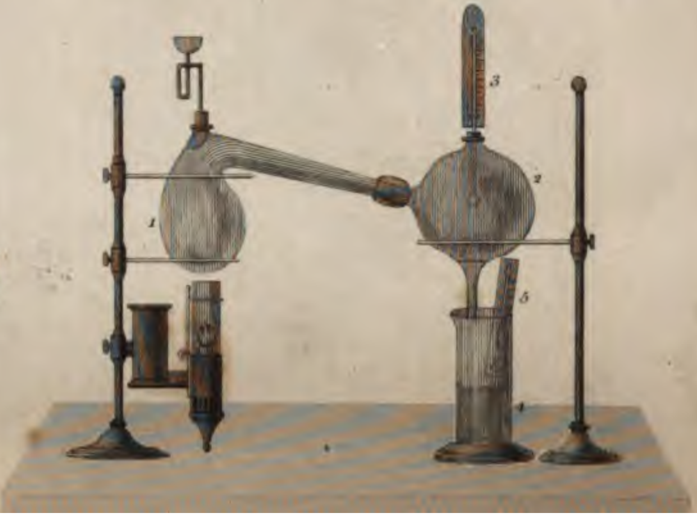
Apparatus for exhibiting the
Reflection of Heat.



1.1. Two Concave Mirrors placed opposite to each other.
2. A Stand supporting a red hot Iron Ball, a piece of kindled Charcoal, or a flask of hot Water.
3. A Stand supporting a Thermometer.
4. The Rays of Heat reflected from the Ball to the Mirror next it: from thence they are refracted to the other Mirror which impinges them

Apparatus for exhibiting the existence of latent heat in Gases.

1. Retort containing Water or other materials for the formation of Gas or vapour.
2. A Balloon in which is inserted
3. A Thermometer to indicate the temperature.
4. A Jar containing Water for the condensation of the Gas.
5. A Thermometer which rises considerably by the evolution of latent heat.



sinking of the thermometer was merely owing to its parting with a certain portion of caloric to the flask, without receiving any in return.

M. Berard has made some delicate experiments on the relative situation and intensity of the heating rays, the rays of light, and the chemical rays. Having substituted a prism of calcareous spar for one of glass, he found that, in each image formed by the prism, the red extremity was hotter than the violet, and this induced him to suspect that the rays of heat underwent a double refraction, in the manner of the rays of light. This idea was streagthened, and ultimately confirmed, by further experiments.

"I received (he says) all the solar rays reflected by the mirror of the heliostata, on a glass plate, at an angle such that the reflected rays were polarized, and these were again received, in their turn, on a second glass, properly inclined. I reunited the rays reflected from this second glass by a metallic mirror, in the focus of which I had an air thermometer. I found that, when the second glass reflected the polarized rays, the thermometer rose; and, when the glass did not reflect the polarized rays, the thermometer rested stationary." This experiment proves, in an evident manner, that the heat which accompanies the solar light is polarized at the same time with the light, and nearly under the same angle.

To ascertain whether the rays of heat proceeding from heated bodies were also polarized in the same manner, M. Berard proceeded as follows: "I placed in the focus of a metallic mirror, three decimeters (about 11.8 inches) in diameter, a lighted taper. I inclined the mirror, so that the parallel rays reflected from it made an angle of 19° 11′ with the horizon. I will suppose, to give clearness to the explanation, that these rays proceeded in the plane of the meridian, from south to north. I received them on a glass, thirty centimeters (11.8 inches) long, and twenty-two (8.7 inches) wide: this glass was disposed so that it reflected the light of the taper downwards, in a perpendicular direction; and beneath it a second similar one was placed parallel to it, which reflected the rays again from the south towards the north. I received these last rays on another metallic mirror, in the focus of which was an air thermometer, having a blackened bulb and a long tube. This mirror and the second glass were fixed together, so that they could be turned round horizontally, without changing their relative positions, or the inclination of the glass. The apparatus being thus disposed, it was easy, by turning the lower glass and mirror round, to ascertain that the light was constantly concentrated on the bulb of the thermometer, sufficient being reflected, even at the position where the greatest quantity was absorbed by the second mirror, to render the focus evident: the taper was then removed, and the whole suffered to cool.

"In the course of some minutes I placed a heated ball of copper, about the size of an egg, exactly in the previous position of the taper; and, at the moment, the air thermometer rose about fifty centimeters (19.7 inches): then, turning the second glass towards the west, the thermometer sunk more and more as it approached that point. I left it some time in that position, and the thermometer returned to within two centimeters of its first point. I continued to turn the second glass, and, as it approached the south, the fluid again rose; where, having left it about a minute, it had mounted to forty-five centimeters (17.7 inches). Continuing the motion of the glass, the thermometer cooled gradually, until it had reached the east; where, remaining two minutes, it regained its original temperature."

This experiment, which was repeated a great number of times, proves, that radiant heat, reflected by a glass, at an angle of about 35°, and falling on a second glass, making the same angle with its surface, is reflected by this second plane, when it is turned in two positions opposite to each other, and is not reflected in two other positions equally opposed, each being intermediate and equally distant from the two first. Radiant heat, therefore, like light, may be polarized.

Some other experiments were instituted, with the view of ascertaining the chemical influence of rays of light, or, as he expresses it, of the chemical rays.—" I received (he says) the chemical rays directed in the plane of the meridian on a glass surface, at an angle of incidence of 35° 6′. The rays reflected by this first glass were received on a second at the same incidence. I found that, when this was turned towards the south, the muriate of silver, exposed to the reflected invisible rays, was blackened in less than half an hour; whilst, if turned towards the west, it was not at all discoloured in ten hours. The chemical rays, therefore, may be polarized like the rays of light, by surfaces of glass under a certain angle, and this angle appears to be nearly the same for both kinds of rays. It is, therefore, to be presumed also, that the chemical rays will suffer double refraction in passing through certain diaphanous bodies."—He proved, by other experiments, that the calorific or heating rays may be polarized by glass surfaces, and that they are affected by metallic surfaces similarly to the rays of light.

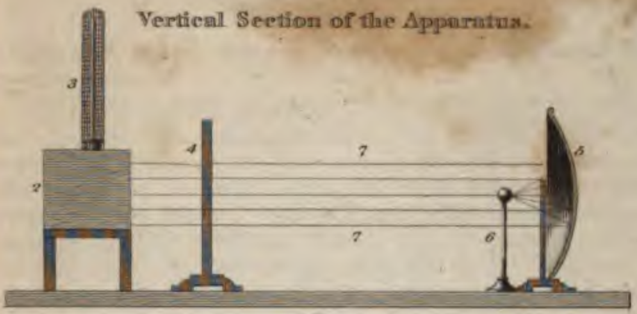
Radiant heat, emitted by hot bodies, is polarized by glass surfaces, when reflected at an equal angle to that, at which light is polarized. Metallic surfaces have a similar action on both kinds of rays. The chemical rays may be polarized by glass surfaces, and possess all the general physical properties of the luminous rays.

DCCXXXIV

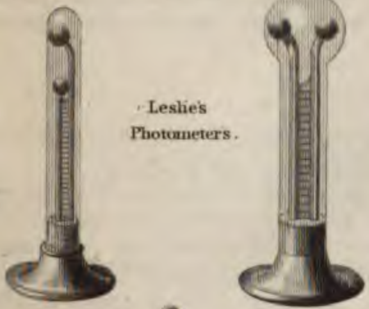
ALL BODIES DO NOT RADIATE ALIKE; FOR, THEIR SURFACES HAVE GREAT POWER IN PROMOTING, OR RETARDING THE MOTION OF CALORIC.

If a cubical canister, four inches square, of polished Tin, be filled with boiling Water, and placed at three feet distance from a concave Tin reflector, which shall have the non-graduated leg of a Differential Thermometer in the focus (see Plate 20;) the quantity of radiated Caloric will

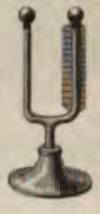
Vertical Section of the Apparatus.

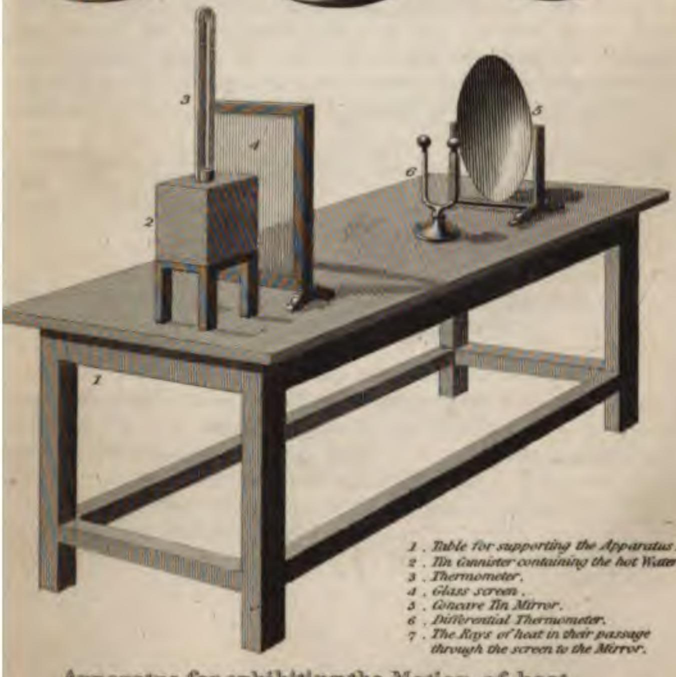


Leslie's
Photometers.



Differential Thermometer.





1 . Table for supporting the Apparatus.
2 . Tin Cannister containing the hot Water.
3 . Thermometer.
4 . Glass screen .
5 . Concave Tin Mirror.
6 . Differential Thermometer.
7 . The Rays of heat in their passage
through the screen to the Mirror.

Apparatus for exhibiting the Motion of heat.

be denoted, by the rising of the fluid in the graduated leg, to about 12° .

But if the canister be brushed over with a mixture of Size and Lamp-black, and again filled with boiling Water, and submitted to the same experiment, the Thermometer will rise to 200°. The experiment may be varied by coating the surface of the canister with different substances, which according to their surfaces, texture or consistency, radiate more or less heat: for example, one side may be blackened, another may have a piece of glass fitted to it, another white Paper, and the last may be naked. Glass, upon the polished surface, will raise the temperature to about 86° or 90°.

DCCXXXV.

If boiling Water be poured into two tea-pots, of the same size; one, bright Silver, or Tin; and the other black Stoneware: (or both metallic, one being covered with a mixture of Glue and Lamp-black, or with a coat of linen, or other substance), and they be left in a room of moderate temperature; one will be warm when the other has become quite cold. The covered, or Stoneware one, will give out its Caloric, and be of the same temperature with the room, in an hour and a half; whilst the metallic surface retards the passage of Caloric from the other, so much, that two hours and a half will elapse, before it is lowered to the same degree.

Observation. This is the reason, that an infusion of tea, or any other herb, is always more perfect in a polished metallic vessel, than in an earthen one.

DCCXXXVI.

MORE HEAT IS RADIATED INTO DARK BODIES, THAN INTO THOSE OF LIGHT COLOUR.

If several pieces of cloth, of different colours, but of equal thickness, are placed on snow, when the Sun shines; so that the rays may fall upon them equally; they will sink downwards, displacing the Snow. Upon examination, the black will be found to have sunk deepest. This can only be accounted for, by the quantity of Caloric which the black absorbs, and which melts the Snow.

DCCXXXVII.

THE SOLAR RAYS POSSESS A HEATING, AS WELL AS AN ILLUMINATING POWER.

If the Solar ray is allowed to fall, through a prism, on the blackened bulb of a Thermometer, the greatest degree of heat will be derived from the red ray in the Spectrum; and it will be found, that if the Thermometer is moved half an inch further than the outer extremity of this ray, the fluid will rise still higher—even upwards of ten degrees in about three minutes of time. But if the Thermometer is moved towards the *violet* ray, the fluid will gradually fall, as it approaches this ray; shewing, that the heating power of the rays decreases from the *red* to the *violet* end. On the contrary, the illuminating power is the greatest in the *central* rays; and decreases towards the extremities.

Observations. LESLIE'S PHOTOMETER (see Plate 20) indicates the intensity of light, by detecting the alteration of temperature occasioned by it. One ball is blown of dark glass, the other is pellucid. The influence of wind is precluded by a case of thin clear glass. The rays of light which strike the dark ball are absorbed, and communicate heat, which by expanding the air forces the liquid downwards in the stem. This sinking will be denoted by the attached scale. A slight modification converts this instrument into a HYGROMETER for measuring the dryness or humidity of the atmosphere. The ball containing the coloured liquid being covered by several coats of tissue paper, and wetted; the depression of the fluid in the opposite stem marks the diminution of temperature caused by exhalation from the humid surface. This will express the relative dryness of the surrounding air.

DCCXXXVIII.

RADIATION OF HEAT IS INFLUENCED BY MOTION, OR THE VELOCITY WITH WHICH A HOT BODY IS MOVED IN A COLD MEDIUM—SUCH AS AIR OR WATER.

If an iron weight (one pound) with a ring attached, be made red-hot in a fire, and left to cool in a room of moderate temperature: a considerable time will elapse before the room and the weight affect the Thermometer equally. But if, when the weight is again heated, a cord be fastened in the ring, to which the hand gives a pendulous motion, (at the rate of six or seven feet in a second of time), it will cool to the temperature of the room, in half the time that it did when at rest:—if an additional impulse be used, so that the motion be sixty feet per second, it will be cold in one-tenth of the time required for the first trial. Blowing air (with as little interruption as possible) from a bellows, upon the Iron, will have a proportional effect. Radiation takes place either when a body is in motion, or at rest; but the cause of the difference in time of cooling, is owing to a continued series of new cold surfaces, being presented to the hot body.

DCCXXXIX.

RADIATED LINES MAY BE IMPEDED IN THEIR PROGRESS, BY THE INTERVENTION OF OTHER BODIES; CONSEQUENTLY, THEY TAKE A LONGER OR SHORTER TIME; OR REQUIRE A REINFORCEMENT OF MORE RAYS, TO PASS THROUGH THEM.

Supposing Experiment 734 to have been begun: place a pane of glass between the blackened canister and the reflector, at two inches distance from the former; the Thermometer will sink 80 degrees, the fluid being at 20°. This shews, that the rays *pervade* the Glass, and still have an effect upon the Thermometer; and we may conclude, that if a more powerful heat could be applied to the canister, the fluid would rise accordingly. (See Plate 20.)

DCCXL.

Instead of Glass, use a deal board, as a screen: the fluid in the Thermometer will be at 9°, or 10°, if the board be about an inch thick.

DCCXLI.

If the Experiment be again repeated; and, instead of the other screens, one of polished Tin, or Tin-foil is used; no Caloric can pass through; consequently, the fluid in the Thermometer will find its own level, and be at 0°. If any of the screens are suddenly withdrawn, the fluid will rise to 90° or 100°.

Observation. In these Experiments, although the Caloric pervades the screens; the only motion it can have, is by Radiation, or by passing in straight lines from the canister, through the screens, to the reflector, and consequently, upon the focal ball of the Thermometer. As for the polished metallic screen; (having no affinity for its surface, because the polish causes reflection,) Caloric cannot radiate through it.—Although Caloric has a great affinity for iron; still, if that iron be polished, and put into a fire, no Caloric will enter, or be radiated into it, until the surface is first blackened or oxidated to a certain degree.

DCCXLII.

DIFFERENCE IN THE CAPACITY OF BODIES FOR HEAT

Place in an oven equal weights of Water, Lead, and Chalk, in three separate basins. Let the Lead and Chalk have cavities in them for the insertion of a Thermometer. When they have been in the oven for some time, examine by the Thermometer the heat of the oven; and then, that of the heated bodies. It will be found, that the Lead will first attain to the heat of the oven, the Chalk next, and the Water last.

Observations. Those bodies which are most slowly heated and cooled are said by Chemists to have, generally, the greatest *capacity for heat*. In the above and similar Experiments it will be found, that the substances most rapidly heated are those which most rapidly cool. Related to the capacities of bodies for heat is their *conducting powers* in regard to heat, or, in other words, the degrees of velocity with which they suffer caloric to pass through them. Amongst solid bodies, metals are the best conductors; and silver, gold, and copper, are better conductors than platinum, iron, and lead. Next to the metals, we may, perhaps, place the diamond and topaz, then glass, then siliceous and hard stony bodies in general, then soft and porous earthy bodies, and wood; and, lastly, down, feathers, and wool. Liquids and gases are very imperfect conductors of heat, and heat is generally distributed through them by a change of specific gravity, as indicated in the Experiments on the ebullition and volatilization of fluids. The influence of the difference in the conducting powers of bodies is shewn in several domestic utensils: and hence wooden handles are given to metallic vessels, or a stratum of ivory or wood interspersed between the hot vessel and the metallic handle. As heat is confined by bad conductors, clothing of woollen materials is worn in cold climates; and the walls of furnaces are composed of clay and sand. Confined air is a bad conductor of heat: hence the advantage of double doors to furnaces; and of a double wall with an interposed stratum of air, to an ice-house. From the different conducting power of bodies arise the sensations of heat and cold experienced upon their application to our bodies, though their real temperature is similar. Thus, air of the temperature of 65 degrees (Fahr.) conveys a sense of warmth, while a bath of the same temperature would be very *cold*. The reason of this diversity is, that water, being a better conductor than air, carries off the heat of the body more rapidly than the latter fluid. It is from the same cause, that diverse surrounding media, when much above the heat of our bodies, affect us with different degrees of heat, although their real temperature be the same. (Here it should be understood, that heat is communicated to the body, not abstracted from it as in the case of media below the temperature of the body). Thus, Sir Joseph Bankes, Dr. Solander, Dr. Crawford, and Sir Charles Blagden, in their Experiments in rooms—the air of which was heated to 200 degrees (Fahr.) and upwards,—found that the air felt but moderately hot; whilst the metallic buttons on their cloaths, the coin in their pockets, &c. *burned* their fingers on being touched: water also felt *scalding* hot; though its real temperature, as marked by the thermometer, was not above that of the surrounding air.

CHAPTER XVI.

PHOSPHORESCENCE OF MINERAL AND ANIMAL SUBSTANCES.

PHOSPHORESCENCE is that property which many Mineral and Animal substances possess, of giving out Light, without the least degree of Heat being perceived. This phenomenon is closely allied with that of Phosphorus, which is well known to shine, or give out a beautiful lambent flame in dark places. Many causes have been assigned for these highly curious effects; but in this place we shall pass them over, and proceed to a detail of the facts themselves, dividing them into two classes, viz. Mineral and Animal.

MINERAL PHOSPHORESCENCE.

DCCXLIII.

CANTON'S PHOSPHORUS; OR, IGNITED SULPHURET *Of Lime.*

To prepare this phosphorescent compound; mix three ounces of clean oyster-shells in powder, with one of flowers of sulphur. When intimately combined, ram the whole very tight into a crucible, which put in a clear fire for half an hour; having, previously, covered the top with a piece of moist clay. When fully ignited, withdraw the crucible from the fire, and when the contents are become cold, uncover them, and enclose them in a phial, or phials, which cork very tight. By exposure to light, or to the direct rays of the sun, or even to an electrical explosion, these phials will shine vividly when taken to a dark place.

Observations. The hour on a watch, or letters in a book, will be readily discerned by this light. Soon, however, this effect will become fainter; but it may always be revived by a fresh exposure to the sun's rays, and by keeping the phial well corked.

DCCXLIV.

TO MAKE PHOSPHURET OF LIME.

Put half an ounce of Phosphorus, cut into small bits, into a glass tube about a foot long; and half an inch in diameter, closed at one end. Fill up with quick Lime grossly powdered, and stop the mouth of the tube loosely. Heat that part of the tube which contains the lime, over a chafing dish, till it be red hot; and then apply the heat of a lamp to the part containing the Phosphorus, which will be a reddish mass.

Observation. If phosphuret of lime be dropped into water, air bubbles will be disengaged; which, on bursting at the surface, will inflame with slight explosions. They consist of phosphureted hydrogen gas. If any of this substance be thrown out in the dark, it will have the appearance of a shower of fire, but cannot burn any thing, as the quantity of phosphorus is too small to produce any sensible heat.

DCCXLV.

BALDWIN'S PHOSPHORUS; OR IGNITED NITRATE OF LIME.

Fuse some Nitrate of Lime in a crucible; and keep it in this state for about ten minutes. When in a cold, and hard state, break the mass into small pieces, and enclose them in a phial well corked. They will, after exposure to the rays of the sun, emit beautiful white light, in the dark.

DCCXLVI.

BOLOGNIAN PHOSPHORUS; OR IGNITED SULPHATE *Of Barytes.*

Heat eight ounces of the Native Sulphate of Barytes, to a state of ignition: when cold, pulverise it in a mortar; and make the powder into a paste, with mucilage of Gum Arabic. Divide this paste into small pieces, of the size of large peas, which, when dried by a moderate heat, expose to the heat of a wind-furnace, by placing them loosely in a crucible with charcoal. The crucible should be covered with moist clay. When cold, a few minutes exposure to the sun's rays will give these pieces the property of shining in the dark, so as to enable the operator to see the hour by his watch.

Observations. The most complete account which we have of mineral phosphorescence, is that recorded by Dr. Brewster in the first volume of the Edinburgh Philosophical Journal. His method of examination was ingenious and accurate. He never reduced the body to powder, but placed a fragment of it upon a thick mass of hot iron; or, in delicate experiments, introduced it into the bottom of a pistol barrel, heated a little below redness.

The following Table presents his results:

Names of the Minerals.	Colour of the Minerals.	Colour and intensity of the Light.
Fluor spar,	Pink,	Green,
———	Purple,	Bluish,
———	Bluish-white,	Blue,
Compact fluor,	Yellowish,	Fine green,
Sandy fluor,	White,	White sparks,
Calcareous spar,	Yellow,	Yellow,
	Transparent,	Yellowish,
Limestone from the north of Ireland,	———	Yellowish-red,
Phosphate of lime,	Pink,	Yellow,
Arragonite,	Dirty white,	Reddish-yellow,
Carbonate of barytes,	Whitish,	Pale white,
Harmotome,	Colourless,	Reddish-yellow,
Dipyre,	White,	Specks of light,
Grammatite from Glentilt,	———	Yellow,
——— from Cornwall,	———	Bluish,
Topaz, Aberdeenshire,	Blue,	Bluish,
——— Brazilian,	Yellow,	Faint yellowish,
——— New Holland,	White,	Bluish,
Rubellite,	Reddish,	Scarlet,
Sulphate of lime,	Yellowish,	Faint light,
——— of barytes,	Yellow,	Pale light,
——— ———	Slate colour,	Pale light,
——— strontites,	Bluish,	A fragment shone pretty bright,
——— lead,	Transparent,	Faint, and by fits,
Anhydrite,	Reddish,	Faint light,
Sodalite,	Dark Green,	Pretty bright,
Bitter spar,	Yellowish,	Faint white,
Red silver ore,	Red,	Pretty bright, but flitting,
Barystrontianite,	White,	Faint,
Arseniate of lead,	Yellowish,	Bright white,
Sphene,	Yellow,	Bright white,
Tremolite,	Whitish,	Reddish-yellow,
Mica,	Greenish,	Whitish,
—— from Waygatz,	Black,	White specks,
———	Brown,	Pretty bright,
Titanium sand,	Black,	Feeble specks,
Hornstone,	Grey,	Yellowish,
Table spar, Dognatska,	Whitish,	Yellowish,
Lapis lazuli,	Blue,	Faint,

Names of the Minerals.	Colour of the Minerals.	Colour and Intensity of the Light.
Spodumene,	Greenish,	Faint,
Titanite,	Reddish,	Extremely faint,
Cyanite,	Yellowish-white,	Bluish,
Calamine,	Brown,	Faint,
Augite,	Green,	Pretty bright,
Petalite,	Reddish tinge,	Blue, and very bright,
Abestos, rigid,	————	Pretty bright,
Datholite,	Transparent,	Bright,
Corundum,	Brown,	Bright,
Anatase,	Dark,	Reddish-yellow,
Tungstate of lime,	Yellowish-white.	Brilt. like a burning coal,
Quartz,	The phosphorescence of these nine minerals was observed in the pistol barrel.	Very faint,
Amethyst,		Faint,
Obsidian,		Pretty bright; dirty blue,
Mesotype from Auvergne,		Very faint,
Glassy Actinolite,		Little specks,
Ruby silver,		Rather bright,
Muriate of silver,		Blue,
Carbonate of copper,		Very faint,
Green Telesie,		Pale blue, & pretty bright.

DCCXLVII.

PHOSPHORESCENCE OF BODIES BY THE ELECTRICAL *Discharge.*

When the electrical discharge is transmitted along the surfaces of certain bodies, or a little above them, a durable phosphorescence is occasioned.

Sulphate of barytes gives	A bright green light,
Carbonate	Do. less brilliant,
Acetate of potass, . .	Brilliant green light,
Succinic acid, ...	Do. more durable.
Loaf sugar, ...	Do.
Selenite, ...	Do. but transient,
Rock-crystal, ...	Light red, and then white,
Quartz, ...	Dull white light,
Borax, ...	Faint green light,
Boracic acid, ...	Bright green light.

Observations. Canton's pyrophorus yields more light by this treatment than any other body; but almost every native mineral, except metallic ores and metals, becomes more or less luminous after the electric explosion. A slate from Colly Weston, Northamptonshire, which effervesced with acids, gives a beautiful effect. When the explosion of a jar is taken *above* the centre of a piece some inches square, not only the part above the discharging-rods is luminous, but the surface of the plate appears bespangled with very minute brilliant points to some distance from its centre; and when the points of the dischargers rest upon the surface of the slate, these minute spangles are detached and scattered about the table in a luminous state

DCCXLVIII.

LUMINOUS CHARACTERS ON WALLS, COATED WITH LIME.

Take a piece of Phosphorus from the bottle in which it is kept, and, during candle-light, write upon a white-washed wall, any sentence or word; or draw upon the same any figure, according to fancy. Withdraw the candle from the room, and direct the attention of the spectators to the writing. Whatever parts the Phosphorus has touched, will be rendered quite luminous, emitting a whitish smoke, or vapour.

Observations. This luminous appearance is doubtless owing to the transfer of particles of the phosphorus to the surface of the wall; but the cause of no heat being given out, is that the phosphorus has combined with the lime, or whiting. Great care must be taken, whilst using the pencil of phosphorus, to dip it frequently in a bason of cold water; if this be not done, the repeated friction will throw it into a state of the most active combustion, to the manifest detriment of the operator. Another precaution is here necessary: viz, not to perform this and similar experiments before timid persons, without previous intimation as to the nature of phosphorus.

DCCXLIX.

TO MAKE PHOSPHORIC OIL.

Put one part of Phosphorus into six of Olive Oil, and digest them by a sand heat. The Phosphorus will dissolve. It must be kept well corked.

Observation. This oil has the property of being luminous in the dark, but has not sufficient heat to burn. If rubbed on the face and hands, (taking care to shut the eyes,) the appearance will be most hideously frightful; all the parts which have been rubbed appearing to be covered by a luminous lambent flame of a bluish colour, whilst the eyes and mouth appear like black spots. No danger attends this experiment. The light is sufficient to shew the hour of the night on a watch, by holding it close to the unstopped bottle.

DCCL.

CURIOUS PHENOMENA EXHIBITED BY TABASHEER.

A substance called *Tabasheer* having some very peculiar properties, has lately excited the attention of the scientific world. This substance is said to be inferior in refracting power to all solid and fluid substances hitherto examined. It readily imbibes all the volatile and fat oils, and indeed all other fluids. The essential oils are quickly absorbed, and, with the exception of oil of cassia, are as quickly evaporated, while the fat oils are slowly drawn in, and remain a long time in its pores; in all these cases an opacity is produced by absorption. When the imbibed fluids have a colour of their own, or are tinged with colouring matter, the Tabasheer exhibits a similar tint, so that it is easy to communicate to it any colour. The opaque Tabasheer, which retains its opacity when its pores are filled with water, acquires a beautiful transparency from the absorption of the oil of beech-nut. It is curious to observe a substance like chalk, and consisting apparently of a number of particles in a state of accidental aggregation, converted into a transparent mass, which the light freely penetrates in every direction.

If this substance be wrapped in a piece of paper, and the paper be set on fire, the Tabasheer becomes either black, or brownish black, and the black colour increases in depth by the repetition of the experiment; if the blackened tabasheer be brought to a red heat, it is restored to its primitive whiteness, and resumes all its former properties.

Observations. Tabasheer is of two kinds: the transparent and the opaque. The specific gravity of the former, when dry, is about 2.412, and of the latter 2.059. The transparent tabasheer has the remarkable property of becoming opaque and white by absorbing a small quantity of water, and perfectly transparent when that quantity is increased. This effect taking place indiscriminately with all fluids, cannot be the result of chemical action, its cause must be, therefore, sought in the changes which the light suffers in traversing the vacuities of tabasheer. From a variety of experiments it is found, that in both kinds of tabasheer, the quantity of water imbibed exceeds in weight that of the tabasheer itself; of course this substance must be extremely porous, and hence arises its peculiar qualities for the transmission of light.

DCCLI.

LUMINOUS EFFECTS OF LIME, AND MAGNESIA, ON WOOD.

Mr. Cameron, of Glasgow, steeped some pieces of wood in Oxymuriate of Lime; and observed a singular luminous property in the white substance which remained after burning the wood. In order to observe this appearance, the end of the piece of wood must be held in the flame of a candle till it is completely burnt. A sort of white substance is left at the end of the wood, and when this is held in the outer part of the flame of a candle, it exhibits a brilliant dazzling light, not much, if at all, inferior to that which arises from the deflagration of Charcoal by the action of Galvanism. When bits of woods of different kinds were steeped in the Oxymuriate of Lime, they gave the same results; only the harder woods seemed to produce a more satisfactory effect than the softer kinds.

By submitting the whole substance to the action of the blow-pipe, the intensity of the light was greatly increased, but the white substance was generally driven away by the blast.

The white residue of the burnt wood consisted of particles of Lime in a state of minute division, and soluble in Nitric Acid. Dr. Fyfe found them to be pure Lime, and ascertained that wood acquired the same property by being steeped in solutions of the salts of that earth, or in lime-water. A similar result was obtained by steeping the wood in a solution of Sulphate of Magnesia; but no effect was produced when it was steeped in a solution of Hydrate of Barytes. The calcareous residue was highly phosphorescent, when thrown upon a hot iron, but the magnesian residue exhibited no symptom of phosphorescence.

Observations. Dr. Brewster observes, that these experiments naturally suggest the idea, that such a brilliant light, capable of being developed by the heat of a candle, might have some useful application. "In order to obtain some information on this point, I prepared three or four pieces of wood terminated by the white masses of absorbed lime, and placed these masses so as to remain near the circumference of the flame of a candle. In this situation they yielded the brilliant light already described, and lasted, without any apparent diminution, for more than two hours. I next prepared a very thin slice of chalk, and having held it in the flame of the candle, I found that it did not give the same brilliant light as the absorbed lime. Upon exposing it, however, to the heat of the blow-pipe, it emitted the same white and dazzling light which has already been described."

DCCLII.

EFFECTS OF THESE SUBSTANCES ON TABASHEER.

In order to observe if the minute particles of the Lime and the Magnesia would remain in the pores of the Tabasheer, and give out their light when laid upon a hot iron; I took two pieces of this substance, and having discharged their natural phosphorescence, by exposing them to a high degree of heat, I placed one of them in Lime-water, and the other in a solution of Sulphate of Magnesia. When the pieces of Tabasheer were dry, I then put them upon a hot iron, and found that the piece which had been placed in the Lime-water was considerably phosphorescent, whilst that which was immersed in the magnesian solution, gave out no light at all.

ANIMAL PHOSPHORESCENCE.

The Glow-worm, and some other luminous insects, are too well known to require description. The phosphorescent appearance of these animals has often been a source of surprise to the inexperienced, who are not aware that it proceeds from their organization. In many parts of America, a similar luminous appearance proceeds from an insect called the Lightning Bug, which is very common in the fields, and on the highways.

That light occasionally proceeds from putrescent animal and vegetable substances, as well as from living glow-worms, &c. was noticed by Aristotle. Columba, long after, observed that several insects emitted light, and that such light is not extinguished immediately upon the death of the animal. But the first distinct account of light proceeding from putrescent animal flesh, is that of three Roman youths, residing at Padua, who had bought a lamb, and had eaten part of it on Easter-day, 1492: several pieces of the remainder, which they kept till the day following, shone when they were casually viewed in the dark. Part of this luminous flesh was immediately sent to Aquapendente, the Professor of Anatomy in that city. He observed, that both the lean and the fat of this meat shone with a whitish kind of light, and also, that some pieces of kid's flesh, which happened to have lain in contact with it, were luminous; as well as the fingers and other parts of the bodies of those persons who touched it. Those parts, he observed, shone most, which were soft to the touch, and seemed to be transparent in candle-light; but where the flesh was thick and solid, or where a bone was near the outside, it did not shine.

Thomas Bartholin mentions four kinds of luminous insects, two of which were possessed of wings, and two wingless, or apterous. He also takes notice of one instance, in which this light was observed to issue from dead matter. This happened at Montpelier in 1641. An old woman had bought a piece of flesh in the market, intending to make use of it on the following day; but happening not to be able to sleep well that night, and her bed and pantry being in the same room, she observed so much light come from the flesh, as to illuminate all the place where it hung. A part of this luminous flesh was carried as a curiosity to the Duke of Condé, Governor of the place, who viewed it for several hours with astonishment.

This light was observed to be whitish; and not to cover the whole surface of the flesh, but certain parts only, as if gems, of unequal splendour, had been scattered over it. This flesh was kept till it began to putrefy, when the light vanished; which, as some religious people fancied, *it did in the form of a cross.*

Boyle tried the effect of his air-pump upon these luminous substances; and found that the light of rotten wood was extinguished in vacuo, and revived again on the admission of the air, even after a long continuance in vacuo.

Among other things, he observed, that this light continued a long time, when a piece of the wood was put into a very small glass, hermetically sealed; and it made no difference when this tube which contained the wood was put into an exhausted receiver. This he also observed with respect to a luminous fish, which he put into water, and placed in the same circumstances. He found, that the light of shining fishes had properties in common with these of shining wood; but the latter, he says, was presently quenched by water, spirit of wine, a great variety of saline mixtures, and by other fluids. Water, however, did not quench all the light of some shining veal, though spirit of wine destroyed it.

In general, he made use of whitings, finding them the fittest for his purpose. In a discourse upon this subject at the Royal Society, in 1681, he asserted, that, of all fishy substances, the eggs of lobsters, after they had been boiled, shone the brightest.

Among other things, Mr. Boyle observes, that extreme cold extinguishes the light of shining wood, as appeared when a piece of it was put into a glass tube, and held in a frigorific mixture; a fact which minutely agrees with Dr. Hulmes' more modern experiments upon dead animal matter. He also found that rotten wood did not waste itself by shining, and that the application of a thermometer to it, did not discover the least degree of heat.

DCCLIII.

LUMINOUS APPEARANCES OF THE PHLOAS.

The shell-fish called Phloas, which forms for itself holes in various kinds of stone, &c. was one of the earliest subjects of attention. That this fish is luminous was noticed by Pliny; who observes, that it shines in the mouth of the person who eats it, and, if it touch his hands or clothes, makes them luminous. He also says, that the light depends upon its moisture.

Reaumur observes, that, while other fishes give light when they tend to putrescence, this is more luminous in proportion to its being fresh; that when it is dried, its light will revive, if moistened either with fresh, or salt water; but that brandy immediately extinguishes it. He endeavoured to make this light permanent, but none of his schemes succeeded.

Beccaria observed, that though this fish ceased to shine when it was putrid; yet that in its most putrid state, it would shine, and make the waters in which it was immersed luminous, when they were agitated. Galeati and Monti found, that wine or vinegar extinguished this light: that in common oil it continued some days; but in rectified spirit of wine, or urine, hardly a minute.

In order to observe in what manner this light was affected by different degrees of heat, they made use of Reaumur's thermometer; and found, that water rendered luminous by these fishes, encreased in light till the heat arrived to 45 degrees; but, that it then became suddenly extinct, and could not be revived.

Observations. In the experiments of Beccaria, a solution of sea salt increased the light of the luminous water, a solution of nitre did not increase it quite so much; sal-ammoniac diminished it a little; oil of tartar nearly extinguished it; and the acids entirely. This water poured upon fresh calcined gypsum, rock crystal, ceruss, or sugar, became more luminous. He also tried the effects of it when poured upon various other substances; but there was nothing very remarkable in them. Afterwards, using luminous milk, he found that oil of vitriol extinguished the light, but that oil of tartar increased it.

DCCLIV

EFFECTS OF THIS LIGHT UPON COLOURS.

Beccaria had the curiosity to try how differently-coloured substances were affected by this kind of light; and having, for this purpose, dipped several ribbons in it, the white came out the brightest; next to this was the yellow; and then the green; the other colours could hardly be perceived. He then dipped boards painted with the different colours, and also glass tubes, filled with substances of different colours, in water rendered luminous by fishes. In both these cases, the red was hardly visible, the yellow was the brightest, and the violet the dullest. But on the boards, the blue was nearly equal to the yellow, and the green more languid; whereas in the glasses, the blue was inferior to the green.

DCCLV.

LUMINOUS APPEARANCE OF THE PHLOADES

In Milk, and Honey.

Of all the liquors into which he put the Phloades, Milk was rendered the most luminous. A single Phloas made seven ounces of Milk so luminous, that the faces of persons might be distinguished by it; and it looked as if it was transparent.

Air appeared to be necessary to this light; for when Beccaria put the luminous Milk into glass tubes, no agitation would make it shine, unless bubbles of air were mixed with it. Monti and Galeati found, that, in an exhausted receiver, the Phloas lost its light, but the water was sometimes made more luminous; which they ascribed to the rising of bubbles of air through it.

Beccaria, as well as Reaumur, had many schemes to render the light of these Phloades permanent. For this purpose, he kneaded the juice into a kind of paste with flour, and found that it would give light when it was immersed in warm water; but it answered best to preserve the fish in Honey. By any other method of preservation, the property of becoming luminous would not continue longer than six months, but in honey it lasted above a year; and then it would, when plunged in warm water, give as much light as ever it had done.

DCCLVI.

LUMINOUS APPEARANCE OF FISH, IN SEA WATER.

From some experiments made by Mr. Canton, he concludes, that the luminousness of sea-water is owing to the slimy, and other putrescent substances, which it contains.

He put a small fresh Whiting into a gallon of sea-water, in a pan about fourteen inches in diameter; and took notice that neither the Whiting nor the water, when agitated, gave any light. A Fahrenheit's thermometer, in the cellar where the pan was placed, stood at 54°. Next night, that part of the fish which was even with the surface of the water was luminous, but the water itself was dark. He drew the end of a stick through it, from one side of the pan to the other, and the water appeared luminous behind the stick all the way, but gave light only where it was disturbed. When all the water was stirred, the whole became luminous, and appeared like milk, giving a considerable degree of light to the side of the pan; and it continued to do so for some time after it was at rest. The water was most luminous when the fish had been in it about twenty-eight hours; but would not give any light by being stirred, after it had been in it three days.

DCCLVII.

COMPARISON IN THE EFFECTS OF FRESH WATER AND *Sea Water on Fish.*

He put a gallon of fresh water into one pan, and an equal quantity of sea-water into another; and into each, he put a fresh herring of about three ounces in weight. The next night, the whole surface of the *sea-water* was luminous, without being stirred; but it was much more so when it was put into motion. The upper part of the herring, which was considerably below the surface of the water, was also very bright: at the same time, the fresh water, and the fish that was in it, were quite dark. There were several bright luminous spots on different parts of the surface of the sea-water; and the whole, when viewed by the light of a candle, seemed covered with a greasy scum. The third night, the light of the sea-water, while at rest, was very little, if at all, less than before; but when stirred, its light was so great as to discover the time by a watch, and the fish in it appeared as a dark substance. After this, its light was evidently decreasing, but was not quite gone before the 7th night. The fresh water and the fish in it, were perfectly dark during the whole time. The thermometer was generally above 60°.

DCCLVIII.

EFFECTS OF A SOLUTION OF SALT IN WATER.

The preceding experiments were made with sea-water;

but he now made use of fresh water, into which he put common, or sea-salt; till he found by an hydrometer, that it was of the same specific gravity with the sea-water; and, at the same time, in another gallon of water, he dissolved two pounds of salt: into each of these waters he put a small fresh herring. The next evening, the whole surface of the artificial sea-water was luminous without being stirred; but gave much more light when it was disturbed. It appeared exactly like the real sea-water in the preceding experiment; its light lasted about the same time, and went off in the same manner. The other water, which was almost as salt as it could be made, never gave any light. The herring which was taken out of it on the seventh night, and washed from its salt, was found firm and sweet; but the other herring was very soft and putrid, much more so than that which had been kept as long in fresh water. If a herring, in warm weather, be put into ten gallons of artificial sea-water, instead of one, the water, he says, will still become luminous, but its light will not be so strong.

Observations. Mr. Canton observes, that though the greatest summer heat is well known to promote putrefaction, yet twenty degrees more than that of the human blood seems to hinder it. For, putting a small piece of luminous fish into a thin glass ball, he found, that water of the heat of 118° would extinguish its light in less than half a minute; that, on taking it out of the water, it would begin to recover its light in about ten seconds; but it was never afterwards so bright as before.

Mr. Canton observed, that several kinds of river fish could not be made to give light, in the same circumstances in which any sea-fish became luminous. He says, however, that a piece of carp made the water very luminous, though the outside, or scaly part of it, did not shine at all.

For the convenience of those persons who may choose to repeat his experiments, he observes, that artificial sea-water may be made without the use of an hydrometer, viz. by the proportion of four ounces avoirdupoise of salt, to seven pints (wine-measure) of water.

LUMINOUS APPEARANCES OF THE SEA.

That the sea is sometimes luminous, especially when it is put in motion by the dashing of oars, or by beating against a ship, has been observed with admiration by a great number of persons. Mr. Boyle, after reciting all the circumstances of this appearance, as far as he could collect them from the accounts of navigators; as its being extended as far as the eye could reach; at other times being visible only when the water was dashed against some other body; that, in some seas, this phenomenon is accompanied by some particular winds, but not in others; and that sometimes one part of the sea will be luminous, when another part, not far from it, will not be so; concludes, that he could not help suspecting that these odd phenomena, belonging to great masses of water, were in some degree owing to some *cosmical law* of the terrestrial globe, or of the planetary vortex.

Father Bourzes, in his voyage to the Indies, in 1704, took particular notice of the luminous appearance of the sea. The light was sometimes so great, that he could easily read the title of a book by it, though he was nine or ten feet from the surface of the water. Sometimes, he could easily distinguish, in the wake of the ship, the particles that were luminous from those that were not; and they appeared not to be all of the same figure. Some of them were like points of light, and others such as stars appear to the naked eye. Some of them were like globes, of a line or two in diameter; and others as big as a person's head. Sometimes they formed themselves into squares of three or four inches long, and one or two broad. Sometimes all these different figures were visible at the same time; and sometimes there were what he calls vortices of light, which at one particular time, appeared and disappeared like flashes of lightning.

Nor did only the wake of the ship produce this light; but fishes also, in swimming, left so luminous a track behind them, that both their size and species might be distinguished by it. When he took some of the water out of the sea, and stirred it with his hand, in the dark, he always saw in it an infinite number of bright particles: the same appearance was exhibited when he dipped a piece of linen in the sea, and wrung it in a dark place, even though it was half dry; and he observed that when the sparkles fell upon any thing that was solid, it would continue shining for some hours together.

This Father observes, that it depends very much upon the quality of the water; and he was pretty sure that this light is the greatest when the water is fattest, and fullest of foam. For in the main sea, he says, the water is not every where equally pure; and that sometimes, if linen be dipped in the sea, it is *clammy* when it is drawn up again: and he often observed, that when the wake of the ship was the brightest, the water was the most *fat and glutinous*; and that linen moistened with it produced a great deal of light, if it was stirred or moved briskly. Besides, in some parts of the sea, he saw a substance like saw-dust, sometimes red and sometimes yellow; and when he drew up the water in those places, it was viscous and glutinous. The sailors told him, that it was the spawn of whales: that there are great quantities of it in the north; and that sometimes, in the night, they appeared all over of a bright light, without being put in motion by any vessel or fish passing by them.

As a confirmation of the justness of this conjecture, that the more glutinous the sea water is, the more it is disposed to become luminous; he observes, that, one day, they took a fish called *bonite*, the inside of the mouth of which was so luminous, that, without any other light, he could read the same characters which he had before read by the light in the wake of the ship; and the mouth of this fish was full of a viscous matter, which, when it was rubbed upon a piece of wood, made it, immediately, all over luminous; though, when the moisture was dried up, the light was extinguished.

The abbé Nollet was much struck with the luminousness of the sea when he was at Venice in 1749; and concluded that it was occasioned by a shining insect. Having examined the water very often, he, at length, did find a small insect, which he particularly describes; and to which he attributes the light. The same hypothesis also occurred to M. Vianelli, professor of medicine in Chioggia, near Venice; and both he and M. Grizellini, a physician in Venice, have given drawings of the insects from which they imagined this light to proceed.

The abbé was the more confirmed in his hypothesis, by observing, some time after, the motion of some luminous particles in the sea. For, going into the water, and keeping his head just above the surface, he saw them dart from the bottom, which was covered with weeds, to the top, in a manner which he thought very much resembled the motions of insects; though, when he endeavoured to catch them, he only found some luminous spots upon his handkerchief, which were enlarged when he pressed them with his finger.

M. Le Roi, making a voyage on the Mediterranean, took notice, that in the day-time the prow of the ship, in motion, threw up many small particles, which, falling upon the water, rolled upon the surface of the sea for a few seconds before they mixed with it; and in the night, the same particles, as he concluded, had the appearance of fire. Taking a quantity of the water, the same small sparks appeared whenever it was agitated; but every successive agitation produced a less effect than the preceding, except after being suffered to rest a short time; for then, a fresh agitation would make it almost as luminous as the first. This water he observed, retained its property of shining by agitation for a day or two; but it disappeared immediately on being set on the fire, though it was not made to boil.

M. Dagelet, a French astronomer, who returned from the Terra Australis in the year 1774, brought with him several kinds of worms, which shone in water, when set in motion; and M. Rigaud affirmed that the luminous surface of the sea, from the port of Brest, to the Antilles, contains an immense quantity of little, round, shining Polypi. Other learned men who acknowledge the existence of these luminous animals, cannot be persuaded to consider them as the cause of all the light and scintillation that appear on the surface of the ocean: they think that such phenomena proceed from putrefaction. M. Godhou published some observations on a fish called *Bonite*, already mentioned; and though he accurately described several of the luminous insects that are found in sea-water, he is, nevertheless, of opinion, that the scintillation, and flaming light of the sea, proceed from the oily and greasy substances with, which it is impregnated.

The abbé Nollet was long of opinion, that the light of the sea proceeded from electricity; though he afterwards seemed inclined to think, that this phenomenon was caused by small animals, either by their luminous aspect, or at least by some liquor, or effluvia, which they emitted. He did not, however, exclude other causes; among these, the spawn or fry of fish deserves to be noticed. M. Dagelet, sailing into the bay of Antogil, in the island of Madagascar, observed a prodigious quantity of fry, which covered the surface of the sea, above a mile in length, and which he, at first, took for banks of sand, on account of their colour; they exhaled a disagreeable odour, and the sea had appeared with uncommon splendour some days before. The same accurate observer, perceiving the sea remarkably luminous, in the road to the Cape of Good Hope, during a perfect calm, remarked, that the oars of the canoes produced a whitish and pearly kind of lustre: when he took in his hand the water which contained these phosphori, he discerned in it, for some minutes, globules of light as large as the heads of pins. When he pressed these globules, they appeared, to his touch, like a soft and thin pulp; and some days after, the sea was covered, near the coasts, with whole banks of these little fish, in innumerable multitudes. The following figures represent sections of these animalculæ.

M. Peron, on his voyage to the Isle of France, observed the *Pyrosoma Atlantica* between three or four degrees of north latitude. Its phosphorescence renders it the most beautiful of the zoophites, and its organization is most singular. The darkness was intense when it was first discovered; the wind blew violently, and the progress of the vessel was rapid. On a sudden there appeared, at some distance, a vast sheet of phosphorus floating on the waves. The vessel having passed through this inflamed part of the sea, the crew discovered that the light was occasioned by an immense number of small animals, which swam at different depths, and assumed various forms. Those which were deepest were like red-hot cannon balls; whilst those on the surface resembled cylinders of red-hot iron. Some of them were caught, and were found to vary in size from three to seven inches. The exterior surface of the animal was bristled with oblong tubercles, shining like diamonds: these seemed to be the principal seat of this wonderful phosphorescence. In the inside, also, there appeared a multitude of oblong narrow glands, which possessed the phosphoric quality in a high degree. The colour of these animals, when in repose, is opal yellow mixed with green; but on the slightest movement of those spontaneous contractions which it exercises, by the least irritation, the animal inflames, and becomes instantly like red-hot iron, of a most brilliant brightness. As it loses its phosphorescence, it passes through a number of tints successively, such as red, purple, orange, green, and azure-blue; this last shade is particularly lively and pure.

A gentleman, who kept a journal of a late voyage to Buenos-Ayres, thus describes similar phenomena: " Since we came into the warm latitudes, we have seen every night, principally when the ship was going fast through the water, a number of luminous bodies, which appear of the size of a man's fist, many of them being like a red-hot cannon ball, but of a paler hue. The whole sea appears full of them, and when disturbed by any moving body, they instantly become luminous. I have frequently pulled them up, two or three at once, on a hook which hung overboard during the night. They were still luminous, about the size and shape of a man's finger, consisting merely of a skin, covered with papillæ, the inside being full of water, which gave them their shape. Sea-fish are often luminous, when swimming during the night."

Phosphoric Meteors.

Some attribute that luminous appearance which goes by the name of Ignis Fatuus to putrefaction. It is observed in boggy places, and near rivers, though sometimes also in dry places. By its appearance, benighted travellers are said to have been sometimes misled into marshy places, bogs, and quagmires, taking the light which they saw before them for a candle at a distance. From this seemingly mischievous property it has been thought, by the vulgar, to be a spirit of a malignant nature, and has been named, accordingly, Will-with-a-wisp, or Jack-with-a-lanthorn; for the same reason also it probably had its Latin name, *ignis fatuus.*

This kind of light is said to be frequent about burying-places, and dung-hills. Some countries are also remarkable for it, as about Bologna, in Italy; and some parts of Spain and Ethiopia. Doctor Shaw, in his Travels to the Holy Land, says, that it appeared in the valleys of Mount Ephraim, and attended him and his company for more than an hour. Sometimes it would appear globular, or in the shape of the flame of a candle; at others it would spread to such a degree, as to involve the whole company in a pale inoffensive light, then contract itself; and suddenly disappear; but in less than a minute would appear again; sometimes running swiftly along, it would expand itself at certain intervals, over more than two or three acres of the adjacent mountains. The atmosphere, from the beginning of the evening, had been remarkably thick and hazy; and the dew, as they felt it on the bridles of their horses, was very clammy and unctuous.

Lights, resembling the ignis fatuus, are sometimes to be met with at sea, skipping about the masts and rigging of ships; and Dr. Shaw informs us, that he has seen these in such weather as that just mentioned, when he saw the ignis fatuus in Palestine. Similar appearances have been observed in various other situations; and we are told of one which appeared about the bed of a woman in Milan, surrounding it, as well as her body, entirely. This light fled from the hand which approached it; but was, at length, entirely dispersed by the motion of the air.

These meteors are now considered as real exhalations from the earth, produced by gas, vapour, or some other attenuated substance, emanating from vegetable, animal, or mineral materials; and combined with the matter of light or heat, or both. Instead of being dense or solid, they are uniformly rare and subtle; and, instead of originating in the loftiest regions of the atmosphere, or beyond its range; are generated, for the greater part, in low marshy plains or valleys. To the fearful and superstitious they are a source of terror.

In Italy, in the Bolognese territory, they are so frequent, in the morassy grounds, that they are to be seen every night; some of them affording as much light as a kindled torch, and others not being larger than the flame of a candle, but all of them so luminous as to shed a lustre on the surrounding objects. They are constantly in motion; but this motion is various and uncertain. They sometimes rise, and at others sink, occasionally disappearing of a sudden, and appearing again in an instant in some other place. They usually hover about six feet from the ground, differing both in figure and size, and spreading out, and contracting themselves, alternately. Sometimes they break, to appearance, into two parts; soon after uniting again in one body; and at intervals float like waves, letting fall portions of ignited matter, like sparks from a fire. They are more frequently observed in winter than in summer, and cast the strongest light in rainy and moist weather. They exist mostly on the banks of brooks and rivers, and in morasses; but are likewise seen on elevated grounds, where they are, however, of a comparatively diminutive size.

In the month of March, 1728, a traveller being in a mountainous road, about ten miles south of Bononia, perceived, as he approached the river Rioverde, between eight and nine in the evening, a light shining very brightly on some stones which lay on the banks. It was elevated about two feet above them; its figure describing a parallelopiped, more than a foot in length, and about six inches high, its longest side lying parallel to the horizon. Its light was so strong that he could distinguish by it, very plainly, a part of a neighbouring hedge, and the water in the river. On a near approach, it changed from a bright red to a yellowish colour; and on drawing still nearer became pale; but when the observer reached the spot, it vanished. On his stepping back, he not only saw it again, but found that the farther he receded, the stronger and more luminous it became. This light was afterwards seen several times, both in spring and autumn, precisely at the same spot, and preserving the same shape.

On the 12th of December, 1776, several very remarkable ignes fatui were observed on the road to Bromsgrove, five miles from Birmingham, a little before day-light. A great many of these lights were playing in an adjacent field, in different directions; from some of which, suddenly sprang up bright branches of light, resembling the explosion of a rocket, filled with many brilliant stars. In the case of the latter, the discharge was supposed to be upward, or vertical, instead of taking the usual direction. The hedge, and the trees on each side, were strongly illuminated. This appearance continued a few seconds only, when the ignes fatui played as before. The spectator was not sufficiently near, to observe whether the apparent explosions were attended with any report.

In the month of December, 1693, between the 24th, and 30th, a fiery exhalation, without doubt generated in the same way with the meteors described above, set fire to sixteen ricks of hay, and two barns filled with corn and hay, at the village of Hartech, in Pembrokeshire. It had frequently been seen before, proceeding from the sea, and in these instances lasted for a fortnight, or three weeks. It not only fired the hay, but poisoned the grass, for the extent of a mile, so as to induce a distemper among the cattle. It was a weak blue flame, easily extinguished, and did not in the least burn any of the men who interposed their endeavours to save the hay; although they ventured, not only close to it, but sometimes into it. All the damage sustained happened, constantly, in the night.

Belonging to this class of meteors is the *draco volans*, a fiery exhalation, frequent in marshy and cold countries. It is most common in summer: and, although principally seen playing near the banks of rivers, or in boggy places; still, it sometimes mounts up to a considerable height in the air, to the no small terror of the amazed beholders. Its appearance is that of an oblong, sometimes roundish, fiery body, with a long tail. It is entirely harmless, frequently sticking to the hands and clothes of spectators, without doing them the least injury. —That curious phenomenon observed by Humboldt in South America, called the Lantern of Maracaybo, is, undoubtedly, analogous to those meteors we have been describing.

CHAPTER XVII.

SPECIFIC GRAVITY.

SPECIFIC Gravity is the relative, comparative, or apparent gravity in any body, in respect to that of an equal bulk or magnitude of another body; denoting that gravity, or weight, which is peculiar to each species or kind of body.

In this sense, a body is said to be specifically heavier than another, when under the same bulk it contains a greater weight than that other; and reciprocally the latter is said to be specifically lighter than the former. Thus, if there are two equal spheres, each one foot in diameter; the one of lead, and the other of wood: since the leaden one is found heavier than the wooden one, it is said to be specifically heavier; and the wooden one specifically lighter.

This kind of gravity is by some called relative; in opposition to absolute gravity, which increases in proportion to the quantity, or mass, of the body.

For Gases, common Air is the standard; thus Air is said to be 1.0000, and any deviation of gravity in other Gases, is noted accordingly: thus Hydrogen Gas is 0.0732. Water is the standard for liquids and solids; it also is stated to be 1.0000, but on a different scale Sulphuric Acid in comparison with it, varies in gravity, from 1.700 to 1.900.

A body specifically heavier than a fluid, loses as much of its weight when immersed in it, as is equal to the weight or a quantity of the fluid of the same bulk or magnitude. Hence, since the specific gravities are as the absolute gravities under the same bulk; the specific gravity of the fluid, will be to that of the body immersed, as the part of the weight lost by the solid, is to the whole weight. And hence the specific gravities of fluids are as the weights lost by the same solid immersed in them.

As bodies specifically heavier than Water, when immersed therein, lose of their absolute weight taken in the Air, what an equal quantity of Water in Air would actually weigh; consequently, *the difference of the weight of any such body, taken first in air, and afterwards in water, will always be the just weight of a quantity of water, equal in bulk and dimensions to those of the body under consideration*; *and will be at all times fairly comparable with it.*

This famous proposition was first discovered by ARCHIMEDES, on the following occasion. HIERO, King of Sicily, ordered his goldsmith a certain quantity of gold to make the crown royal. It was indeed well designed and finely embellished; but the artist it seems had made free with some of his Majesty's gold, and had substituted in its room an equal quantity of silver, or copper. On delivery of the work, a suspicion of mal-practice arose; the crown was ordered to be surveyed, and the case was referred to ARCHIMEDES, with instructions by no means to deface the workmanship. It lay long before this mathematician, and the maker thought himself pretty secure of his payment. It happened, however, one day, as the philosopher was stepping into a bath, that he took notice that the water rose in the bath in proportion to the part of his body immersed. From this accidental observation he received a hint, wherewith he was so transported, that, he jumped out of the bath, and ran, naked, about the streets of Syracuse, crying in a wild manner, Ευρηκα! Ευρηκα! *I have found it! I have found it!*

In consequence of this speculation, he made two masses of the same weight as the crown; one of gold, the other of silver. These he severally let down carefully into a vessel of water, wherein the rise of the fluid might easily be determined by measure. Being of different specific gravities, they were, consequently, of different magnitudes, and, on immersion took up the room of different quantities of water; by comparing these effects with their absolute gravities in the air, he became fully master of the relation in point of weight, which each of these metals had to water, and consequently to each other. He then examined the crown in the same manner; and by comparing his observations, he at length, detected the cheat, and accurately ascertained the quantities of gold and silver which it contained.

DCCLIX.

THE SPECIFIC GRAVITY OF A SOLID, DENOTED BY THE *Displacement of Water.*

To determine the specific gravity of solids, fill a phial with water, and mark the weight of the whole accurately, in *grains.* Now weigh 100 grains of the substance to be examined, and drop it gradually into the water, in the phial. The difference in weight, of the bottle with its contents now, and when it was filled only with water, will determine the specific gravity of the substance under examination. For example, if the bottle weighs 40 grains more than it did when it was filled with water only, it shows that 100 grains of the mineral displace only 60 grains of water; and, consequently, that it is of nearly twice the specific gravity of water.

Observations. It may here be remarked, that there are very few, if any, *animals,* of themselves, specifically heavier than common water. The *real substances,* indeed, both of animals and vegetables frequently are so: and the floating of either is generally owing to the cells, or receptacles, interspersed in them; which in the one are filled with air or oil, and in the other with air or resin: these being all lighter will swim in water. If then flesh and bones are of themselves somewhat heavier, the fluids and the fat are somewhat lighter; to which if we add the large quantity of air every where included in these cells, they will be found, together, a good deal lighter than a comparative bulk of common water. Besides, as the bulk of the body is capable of being increased by distending the chest in inspiration, a good quantity of air may be taken into it, and this is a farther advantage to the floating animal.

It has been tried by a fat man of ordinary size, what weight he could bring up from the bottom of the Thames, so as to have the top of his head just appear above water. When his breast was full of air, he was found to rise with thirteen pounds of lead, without striking out in the least; and two ounces more would have kept him under: but when his breast was not distended, he could bring up only eleven pounds in that manner.

It is, therefore, difficult to conceive how people, not encumbered with their clothes, should be so often drowned as they are, against their wills; and, unless by struggling unartfully, and admitting water by their mouths, they are suffocated, the thing would seem impossible. One unavoidable disadvantage, indeed, they labour under, and that is from the sudden contraction of the warm air within the body, on its first immersion in cold water; to supply the place of which, they are apt to distend their lungs immediately, and are in a manner forced to gasp for breath; when meeting with a fluid too gross for respiration, they fall a sacrifice to their fears, for want of that presence of mind which brutes, whose apprehensions of the danger being less, are evidently masters of.

HINTS FOR LEARNING TO SWIM, BY DR. FRANKLIN,

In a Letter to a Friend.

Dear Sir.—I cannot be of opinion with you, that it is too late in life for you to learn to swim: the river, near the bottom of your garden, affords a most convenient place for the purpose. And, as your new employment requires your being often on the water, of which you have such a dread, I think you will do well to make the trial; nothing being so likely to remove those apprehensions, as the consciousness of an ability to swim to the shore in case of an accident, or of supporting yourself in the water till a boat could come to take you up.

I do not know how far corks or bladders may be useful in learning to swim, having never seen much trial of them. Possibly, they may be of service in supporting the body while you are learning what is called the *stroke*, or that manner of drawing in and striking out the hands and feet, that is necessary to produce progressive motion. But you will be no swimmer till you can place some confidence in the power of the water to support you; I would therefore advise your acquiring that confidence in the first place, especially as I have known several persons, who, by a little of the practice necessary for that purpose, have insensibly acquired the stroke, taught as it were by nature.

The practice, I mean, is this: chusing a place where the water deepens gradually, walk coolly into it, till it is up to your breast; then turn your face round to the shore, and throw an egg into the water between you and the shore. It will sink to the bottom, and be easily seen there, as your water is clear. It must lie in the water so deep, as that you cannot reach it, to take it up by diving for it. To encourage yourself in order to this, reflect that your progress will be from deeper to shallower water; and that, at any time, you may, by bringing your legs under you, and standing on the bottom, raise your head far above the water. Then plunge under it with your eyes open, throwing yourself towards the egg, and endeavouring, by the actions of your hands and feet against the water, to get forward, till within reach of it. In this attempt you will find, that the water buoys up against your inclination; that it is not so easy a thing to sink, as you imagined; and that you cannot, but by active force, get down to the egg. Thus, you feel the power of the water to support you, and learn to confide in that power; while your endeavours to evercome it, and to reach the egg, teach you the manner of acting on the water with your feet and hands, which action is afterwards used, in swimming, to support your head higher above water, or to go forward through it.

I would the more earnestly press you to the trial of this method, because, though I think I satisfied you, that your body is lighter than water, and that you might float in it a long time, with your mouth free for breathing, if you would put yourself in a proper posture, and would be still, and forbear struggling; yet, till you have obtained this experimental confidence in the water, I cannot depend on your having the necessary presence of mind to recollect that posture, and the directions I gave you relating to it. The surprise may put all out of your mind. For, though we value ourselves on being reasonable knowing creatures, reason and knowledge seem, on such occasions, to be of little use to us; and the brutes, to whom we allow scarce a glimmering of either, appear to have the advantage of us.

I will, however, take this opportunity of repeating those particulars to you, which I mentioned in our last conversation; as, by perusing them at your leisure, you may, possibly, imprint them so on your memory, as, on occasion to be of some use to you.

First, That, though the legs, arms, and head of a human body, being solid parts, are something heavier than *fresh* water, yet the trunk, particularly the upper part, from its hollowness, is so much lighter than water, that the whole of the body taken together, is too light to sink wholly under water, but some part will remain above, until the lungs become filled with water: this happens from drawing water into them, instead of air, when a person, in the fright, attempts breathing, whilst the mouth and nostrils are under water.

2dly, That the legs and arms are specifically *lighter* than *salt* water, and will be supported by it; so that a human body would not sink in salt water, though the lungs were filled as above, but from the greater specific gravity of the head.

3dly, That, therefore, a person throwing himself on his back in salt water, and extending his arms, may easily lie so as to keep his mouth and nostrils free for breathing; and, by a small motion of his hands, may prevent turning, if he should perceive any tendency to it.

4thly, That, in fresh water, if a man throws himself on his back, near the surface, he cannot long continue in that situation, but by a proper action of his hands on the water. If he uses no such action, the legs and lower part of the body will gradually sink till he comes into an upright position, in which he will continue suspended, the hollow of the breast keeping the head uppermost.

5thly, But if, in this erect position, the head is kept upright above the shoulders, as when we stand on the ground, the immersion will, by the weight of that part of the head that is out of the water, reach above the mouth and nostrils, perhaps a little above the eyes, so that a man cannot long remain suspended in water with his head in that position.

6thly, The body continuing suspended as before, and upright, if the head be leaned quite back, so that the face looks upwards, (all the back part of it being under water, and its weight consequently in a great measure supported by it,) the face will remain above water quite free for breathing, will rise an inch higher every inspiration, and will sink as much every expiration, but never so low as that the water may come over the mouth.

7thly, If, therefore, a person unacquainted with swimming, and falling accidentally into the water, could have presence of mind sufficient to avoid struggling and plunging, and to let the body take this natural position, he might continue long safe from drowning, till perhaps help would come. For, as to the cloaths, their additional weight while immersed is very inconsiderable, the water supporting it; though, when he comes out of the water, he would find them very heavy indeed. But, as I said before, I would not advise you, or any one, to depend on having this presence of mind on such an occasion, but learn fairly to swim, as I wish all men were taught to do in their youth; they would, on many occurrences, be the safer for having that skill; and on many more be the happier, as freer from painful apprehensions of danger; to say nothing of the enjoyment in so delightful and wholesome an exercise. Soldiers particularly should, methinks, all be taught to swim; it might be of frequent use, either in surprising an enemy, or in saving themselves. And, if I had boys now to educate, I should prefer those schools (other things being equal) where an opportunity was afforded for the attainment of this highly useful, and delightful exercise.—I am, &c.

B. FRANKLIN.

ACCOUNT OF DANIEL'S LIFE PRESERVER.

The body of the machine, which is double throughout, is made of pliable water-proof leather; large enough to encircle the body of the wearer, whose head is to pass between two fixed straps, which rest upon the shoulder. The arms of the wearer pass through the spaces on the outside of the straps; one on each side, admitting the machine under them to encircle the body like a large hollow belt. The strap on the lower part of the machine is attached to the back of it, and by passing betwixt the thighs of the wearer, and buckling, holds the machine sufficiently firm to the body, without too much pressure under the arms. The machine being thus fixed, is inflated with air by the bearer blowing from his lungs, through a cock, a sufficient quantity of air to fill the machine, which air is retained by turning the stop-cock. The machine, when filled with air, will displace a sufficient quantity of water to prevent four persons from sinking under water.

DCCLX.

TO FIND THE SPECIFIC GRAVITY OF A FLUID OR OF A SOLID.

On one arm of a balance suspend a globe of lead by a fine thread; and to the other fasten an equal weight, which may just balance it in the open air. Immerse the globe in the fluid, and observe what weight balances it then, and consequently what weight is lost, which is proportional to the specific gravity as above. And thus, the proportion of the specific gravity of one fluid to another is determined by immersing the globe successively in all the fluids, and observing the weights lost in each, which will be the proportions of the specific gravities of the fluids sought.

Observation. This same operation determines also the specific gravity of the solid immersed, whether it is a globe, or of any other shape or bulk, supposing that of the fluid known. For the specific gravity of the fluid is to that of the solid. as the weight lost is to the whole weight.

DCCLXI.

TO FIND THE SPECIFIC GRAVITY OF A SOLID THAT IS *Lighter than the Fluid in which it is immersed.*

Annex to the lighter body another that is much heavier than the fluid, so that the compound mass may sink in the fluid. Weigh the heavier body and the compound mass separately, both in water and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater.

Then, As this last remainder
Is to the weight of the light body in air,
So is the specific gravity of the fluid
To the specific gravity of that body.

Observations. The object of the hydrostatical balance is to ascertain the specific gravity of minerals, &c. without calculation. It is a common steelyard, the shorter arm of which is undivided, while the longer arm has engraven on it a scale; every division of which, reckoning from the extremity of the steel-yard, is marked with a number which is the quotient of the length of the whole scale, divided by the distance of the division from the end. Thus, 2 is placed at half the length, 3 at one-third of the length, and so on, up to the specific gravity of platinum. When the instrument is used, any convenient weight is suspended by a hook from the notch at the end of the longer arm. The mineral is then hung at the other end by a horse-hair, until it is in equilibrio with the weight. It is then immersed in water, without changing its place on the steel-yard, and an equilibrium is obtained, a second time, by shifting the weight; and when this is obtained, the hook of the weight will point out the specific gravity on the scale.

Guyton's gravimeter is executed in glass, and is of a cylindric form, being that which requires the smallest quantity of fluid. and is on that account preferable, except so far as it is necessary to deviate for the security of a vertical position. It carries two basins; one of them superior, at the extremity of a thin stem; towards the middle of which the fixed point of immersion is marked. The other, or lower basin, terminates in a point; it contains the balls, and is attached to the cylinder by two branches. The moveable suspension by means of a hook has the inconvenience of shortening the lever which is to secure the vertical position.

The cylinder is 22 millimetres (0.71 inch) in diameter; and 21 centimetres (6.85 inches) in length. It carries in the upper basin an additional constant weight of five grammes (115 grains.) These dimensions might be increased so as to render it capable of receiving a much more considerable weight; but this is unnecessary. M. Guyton has added a piece which he calls the plongeur, because in fact it is placed in the lower basin when used, and is consequently entirely immersed in the fluid. It is a bulb of glass loaded with a sufficient quantity of mercury, in order that its total weight may be equal to the constant additional weight added to the weight of the volume of water displaced by this piece. It will be readily understood that the weight being determined at the same temperature at which the instrument was originally adjusted, it will sink to the same mark on the stem, whether it is loaded with a constant additional weight in the upper basin, or whether the effect of this weight be produced by the additional piece in the lower dish.

This instrument may be readily constructed by any workman in glass. The additional piece for the lower basin will require some attention to make it perfectly agree with the constant upper weight, as to the immersion of the instrument. But this object may, by careful adjustment, be ascertained with the utmost certainty and accuracy. The bulb or glass, is for this purpose, drawn out to a fine point: a sufficient quantity of mercury is then introduced to sink it, and the aperture is closed with a little piece of wax. The bulb being then placed in the lower basin of the instrument, the upper basin is to be loaded until the mark on the stem becomes accurately coincident with the surface of the water. The sum of the weights added above is precisely equal to that of the quantity of mercury necessary to be added to that in the glass bulb; which done, nothing more is needed than to seal the point by fusion, taking care not to change its bulk.

The whole is rendered portable by means of a case, in which all the delicate parts are secured from pressure, and the heavier parts supported in such a manner as to resist the excess of motion they are capable of acquiring by virtue of their mass. This last circumstance is frequently overlookeed by such workmen as are employed in the package of instruments; whence it necessarily follows, that some strain or fracture must be produced when matters of very unequal density are exposed to receive a common impulse.

DCCLXII.

TO FIND THE SPECIFIC GRAVITY OF ANY SOLID BY THE *Gravimeter.*

From the weight in the upper dish, when the instrument is properly immersed in the unknown fluid, take the weight which is placed with the body in the same scale, at the like adjustment. The remainder is the absolute weight of the solid. Multiply this by the specific gravity of the fluid, and reserve the product. From the additional weight, when the body is placed in the lower basin, take the weight when it was placed in the upper. The remainder will be the loss of weight by immersion. Divide the reserved product by the loss of immersion, and the quotient will be the specific gravity of the solid, with regard to distilled water, at the standard temperature and pressure.

DCCLXIII.

TO FIND THE SPECIFIC GRAVITY OF A FLUID BY THE *Gravimeter.*

To the weight of the Gravimeter add the weight required in the upper basin to sink it in the unknown fluid. Again, to the weight of the Gravimeter add the weight required in the same manner to sink it in distilled water. Divide the first sum by the latter, and the quotient will be the specific gravity of the fluid in question.

The specific gravities of bodies, of equal weight, are reciprocally proportional to the quantities of weight lost in the same fluid. And hence is found the ratio of the specific gravities of solids, by weighing in the same fluids, masses that weigh equally in air, and noting the weights lost by each. The specific gravities of many kinds of bodies, both solid and fluid, have been determined by various authors. It will be sufficient here to give those that have been determined with the greatest certainty. The numbers in this table express the number of avoirdupoise ounces *in a cubic foot of each body*, that of common water being just 1000 ounces, or 62½ lbs.

TABLE OF THE SPECIFIC GRAVITIES OF DIFFERENT BODIES.

METALS.

Antimony, crude	4.064	Gold, trinket standard, 20 carats, not hammered	15.709
—— glass of	4.946	—— the same hammered	15.775
—— molten	6.702	Iron, cast	7.207
Arsenic, glass of, natural	3.594	—— bar, either hardened or not	7.788
—— molten	5.763	Steel, neither tempered nor hardened	7.833
—— native orpiment	5.452	—— hardened, but not tempered	7.840
Bismuth, molten	9.823	—— tempered and hardened	7.818
—— native	9.020	—— ditto, not hardened	7.816
—— ore of, in plumes	4.371	Iron, ore prismatic	7.35[illegible]
Brass, cast, not hammered	8.396	—— ditto, specular	5.218
—— ditto, wire-drawn	8.544	—— ditto, lenticular	5.012
—— cast, common	7.824	Lead, molten	11.352
Cobalt, molten	7.812	—— ore of, cubic	7.587
—— blue glass of	2.441	—— ditto, horned	6.072
Copper, not hammered	7.788	—— ore of black lead	6.745
—— the same wire-drawn	8.878	—— ditto, white lead	4.059
—— ore of soft copper, or natural verdigrease	3.572	—— ditto, vitreous	6.558
Gold, pure, of 24 carats, melted, but not hammered	19.258	—— ditto, red lead	6.027
—— the same hammered	19.362	—— ditto, saturnite	5.925
—— Parisian standard, 22 carats, not hammered	17.486	Manganese, striated	4.756
—— the same hammered	17.589	—— metallic	6.850
—— guinea of Geo. II.	17.150	Molybdena	4.738
—— guinea of Geo. III.	17.629	Mercury, solid, or congealed	15.632
—— Spanish gold coin	17.655	—— fluent	13.568
—— Holland ducats	19.352		

Mercury, natural oxide of	9.230
——— precipitate per se	10.871
——— precipitate, red	8.399
——— brown cinnabar	10.218
——— red cinnabar	6.902
Nickel, molten	7.807
——— ore of, called kupfernickel of Saxe	6.648
——— kupfernickel of Bohemia	6.607
Platina, crude, in grains	15.602
——— purified, not hammered	19.500
——— purified, hammered	20.337
——— ditto, wire-drawn	21.042
——— ditto, rolled	22.069
Silver, virgin, 12 deniers, fine, not hammered	10.744
Silver, ditto, hammered	10.511
——— Paris standard	10.175
——— shilling of Geo. II.	10.000
——— shilling of Geo. III.	10.534
——— French coin	10.408
Tin, pure Cornish, melted, and not hardened	7.291
——— the same hardened	7.299
——— of Malacca, not hardened	7.296
——— the same hardened	7.307
——— ore of, red	6.935
——— ore of, black	6.901
——— ore of, white	6.008
Tungsten	6.066
Uranium	6.440
Wolfram	7.119
Zinc, molten	7.191

PRECIOUS STONES.

Beryl, or aqua-marine, oriental	3.549
——— ditto, occidental	2.723
Chrysolite, of the jewellers	2.782
——— of Brazil	2.692
Crystal, pure rock of Madagascar	2.653
——— of Brazil	2.653
——— European	2.655
——— rose-coloured	2.670
——— yellow	2.654
——— violet, or amethyst	2.654
——— white amethyst	2.651
——— Carthagenian	2.657
——— black	2.654
Diamond, white oriental	3.521
——— rose-coloured oriental	3.531
——— orange ditto	3.550
——— green ditto	3.524
——— blue ditto	3.525
——— Brazilian	3.444
——— yellow	3.519
Emerald of Peru	2.775
Garnet of Bohemia	4.189
——— of Syria	4.000
——— dodecaedral	4.063
——— volcanic, 24 faces	2.468
Girasol	4.000
Hyacinth, common	3.687
Jargon of Ceylon	4.416
Quartz, crystallized	2.655
——— in the mass	2.647
——— brown crystallized	2.647
——— fragile	2.640
——— milky	2.652
——— fat, or greasy	2.646
Ruby, oriental	4.283
——— spinell	3.760
——— ballas	3.646
——— Brazilian	3.531
Sapphire, oriental	3.994
——— ditto white	3.991
——— of Puys	4.077
——— Brazilian	3.131
Spar, white sparkling	2.595
——— red ditto	2.438
——— green ditto	2.704
——— blue sparkling	2.693
——— green and white ditto	3.105
——— transparent ditto	2.564
——— adamantine	3.873
Topaz, oriental	4.011
——— pistachio ditto	4.061
——— Brazilian	3.536
——— of Saxe	3.564
——— white ditto	3.554
——— vermilion	4.230

Silicious Stones.

Agate, oriental	2.590	Jasper, violet	2.711
—— onyx	2.638	—— cloudy	2.736
—— cloudy	2.625	—— veined	2.696
—— speckled	2.607	—— onyx	2.816
—— veined	2.667	—— red and yellow	2.750
—— stained	2.632	—— bloody	2.628
Chalcedony, common	2.616	Onyx	2.376
—— transparent	2.664	Opal	2.114
—— veined	2.606	Pearl, virgin, oriental	2.684
—— reddish	2.665	Pebble, onyx	2.664
—— blueish	2.581	—— of Rennes	2.654
—— onyx	2.615	—— English	2.609
Cornelian, pale	2.630	—— veined	2.612
—— speckled	2.612	—— stained	2.587
—— veined	2.623	Prasium	2.581
—— onyx	2.623	Sardonyx, pure	2.603
—— stalactite	2.598	—— pale	2.606
—— simple	2.613	—— speckled	2.621
Corundum	3.000	—— veined	2.595
Flint, white	2.594	—— onyx	2.595
—— black	2.582	—— blackish	2.628
—— veined	2.612	Schorl, black prismatic hexaedral	3.364
—— Egyptian	2.565	—— octaedral	3.226
Jade, white	2.950	—— tourmalin of Ceylon	3.054
—— green	2.966	—— antique basaltes	2.923
—— olive	2.983	—— Brazilian emerald	3.156
Jasper, clear green	2.539	—— cruciform	3.286
—— brownish green	2.681	Stone, paving	2.416
—— red	2.661	—— cutler's	2.111
—— brown	2.691	—— grind	2.134
—— yellow	2.710		

Various Stones, Earths, &c.

Alabaster, oriental white	2.730	Asbestos, ripe	2.578
—— ditto semi-transparent	2.762	—— starry	3.073
—— yellow	2.699	Barytes	4.200
—— stained brown	2.744	Basaltes from Giants' Causeway	2.864
—— veined	2.691	Bitumen, of Judea	1.104
—— of Piedmont	2.693	Brick	2.000
—— of Malta	2.699	Chalk, Spanish	2.790
—— Spanish saline	2.713	—— coarse Briançon	2.727
—— of Valencia	2.638	—— British	2.784
—— of Malaga	2.876	Fluor spar	3.180
Alumine	2.000	Gypsum, opaque	2.168
Amber, yellow transparent	1.078	—— semi-transparent	2.306
Ambergris	.926	—— fine ditto	2.274
Amianthus, long	.909	—— rhomboidal	2.311
—— short	2.313	—— ditto 10 faces	2.312

Gypsum, cuneiform crystallized	2.306
Glass, green	2.642
—— white	2.892
—— bottle	2.733
—— Leith crystal	3.189
—— fluid	3.329
Granite, red Egyptian	2.664
—— of Balbeck	3.500
Hone, white razor	2.876
Lapis nephriticus	2.894
—— lazuli	3.054
—— hæmatites	4.360
—— calaminaris	5.000
—— Judaicus	2.500
—— manati	2.270
Lime, pure	2.300
Limestone	3.179
—— white flour	3.156
—— green	3.182
Magnesia	2.300
Marble, green Campanian	2.742
—— red	2.724
—— white Carrara	2.717
—— white Parian	2.838
—— Pyrenean	2.726
—— black Biscayan	2.695
—— Brocatelle	2.650
—— Castilian	2.700
—— Valencian	2.710
—— white Grenadan	2.705
—— Siennien	2.678
—— Roman violet	2.755
—— African	2.708
—— violet Italian	2.858
—— Norwegian	2.728
—— Siberian	2.718
—— green Egyptian	2.668
—— Swisserland	2.714
—— French	2.649
Obsidian stone	2.348
Peat, hard	1.329
Ponderous spar	4.474
Porcelain, Seves	2.146
—— Limoges	2.341
—— China	2.385
Porphyry, red	2.765
—— green	2.676
—— red, from Dauphiny	2.793
—— red, from Cordone	2.754
Porphry, green, from ditto	2.728
Pyrites, coppery	4.954
—— feruginous cubic	3.900
—— ditto round	4.101
—— ditto of St. Domingo	3.440
Serpentine, opaque, green Italian	2.430
—— ditto, veined black and olive	2.594
—— ditto, red and black	2.627
—— semi-transparent grained	2.586
—— ditto, fibrous	3.000
—— ditto, from Dauphiny	2 669
Silex	2.660
Slate, common	2.672
—— new	2.854
—— black stone	2.186
—— fresh polished	2.766
Stalactite, transparent	2.324
—— opaque	2.478
Stone, pumice	.915
—— prismatic basaltes	2.722
—— touch	2.415
—— Siberian blue	2.945
—— oriental ditto	2.771
—— common	2.520
—— Bristol	2.510
—— Burford	2.049
—— Portland	2.496
—— rag	2.470
—— rotten	1.981
—— hard paving	2.460
—— mill	2.500
—— clicard, from Brachet	2.357
—— ditto, from Ouchain	2.274
—— Notre Dame	2.378
—— St. Maur	2.034
—— St. Cloud	2.201
Strontian	3.700
Sulphur, native	2.033
—— molten	1.991
Talc, of Muscovy	2.792
—— black crayon	2.089
—— ditto German	2.246
—— yellow	2.655
—— black	2.900
—— white	2.704
Zizcon	4.300

LIQUORS, OILS, &c.

Acid, sulphuric	1.841
—— ditto, highly concentrated	2.125
—— nitric	1.271
—— ditto, highly concentrated	1 580
—— muriatic	1.194
—— red acetous	1.025
—— white acetous	1.014
—— distilled ditto	1.010
—— fluoric	1.500
—— acetic	1.063
—— phosphoric	1.558
—— formic	.994
Alcohol, commercial	.837
—— highly rectified	.829
Alcohol, mixed with water,	
15-16ths alcohol	.853
14-16ths ditto	.867
13-16ths ditto	.882
12-16ths ditto	.895
11-16ths ditto	.904
10-16ths ditto	.920
9-16ths ditto	.932
8-16ths ditto	.943
7-16ths ditto	.952
6-16ths ditto	.960
5-16ths ditto	.967
4-16ths ditto	.973
3-16ths ditto	.979
2-16ths ditto	.985
1-16th ditto	.997
Ammonia, liquid	.897
Beer, pale	1.024
—— brown	1.038
Cyder	1.018
Ether, sulphuric	.739
—— nitric	.909

Ether, muriatic	.730
—— acetic	.860
Milk, woman's	1.020
—— cow's	1.032
—— ass's	1.036
—— ewe's	1.041
—— goat's	1.035
—— mare's	1.034
—— cow's clarified	1.019
Naphtha, Persian	.753
—— ditto distilled from Coals in London	.817
Oil, essential of turpentine	.870
—— ditto, of lavender	.834
—— ditto, of cloves	1.036
—— ditto, of cinnamon	1.044
—— of olives	.915
—— of sweet almonds	.917
—— of filberts	.916
—— linseed	.940
—— of walnuts	.923
—— of whale	.923
—— of hempseed	.926
—— of poppies	.924
—— rapeseed	.919
Spirit of wine. See Alcohol.	
Turpentine, liquid	.991
Urine, human	1.011
Water, rain	1.000
—— distilled	1.000
—— sea (average)	1.026
—— of Dead Sea	1.240
Wine, Burgundy	.992
—— Boardeaux	.994
—— Madeira	.993
—— Port	.997
—— Canary	1.033

RESINS, GUMS, AND ANIMAL SUBSTANCES, &c.

Aloes, socotrine	1.380
—— hepatic	1.359
Assafœtida	1.328
Bees'-wax, yellow	.965
—— white	.969
Bone of an ox	1.656
Butter	.942
Calculus, human	1.700
—— ditto	1.240
—— ditto	1.434

Camphor	.989
Copal, opaque	1.140
—— Madagascar	1.060
—— Chinese	1.063
Crassamentum, of the human blood	1.126
Dragon's blood	1.205
Elemi	1.018
Fat, beef	.923
—— hog's	.937

Fat, mutton	.924	Indigo	.769
—— veal	.934	Ivory	1.826
Galbanum	1.212	Juice of liquorice	1.722
Gamboge	1.222	—— of acacia	1.515
Gum, ammoniac	1.207	Labdanum	1.186
—— Arabic	1.452	Lard	.948
—— euphorbia	1.124	Mastic	1.074
—— seraphic	1.201	Myrrh	1.360
—— tragacanth	1.316	Opium	1.336
—— bdellium	1.372	Phosphorus	1.714
—— scammony of Smyrna	1.274	Serum of human blood	1.030
—— ditto of Aleppo	1.235	Spermaceti	.943
Gunpowder, shaken	.932	Storax	1.110
——— in a loose heap	.836	Tallow	.942
——— solid	1.745	Terra Japonica	1.398
Honey	1.450	Wax, shoemaker's	.897

WOODS.

Alder	.800	Juniper-tree	.556
Apple-tree	.793	Lemon-tree	.703
Ash, the trunk	.845	Lignum-vitæ	1.333
Bay-tree	.822	Linden-tree	.604
Beech	.852	Logwood. See Campechy.	
Box, French	.912	Mastich-tree	.849
—— Dutch	1.328	Mahogany	1.063
—— Brazilian red	1.031	Maple	.750
Campechy wood	.913	Medlar	.944
Cedar, wild	.596	Mulberry, Spanish	.897
——— Palestine	.613	Oak, heart of, 60 years	
——— Indian	1.315	old	1.170
——— American	.561	—— Dry oak	.925
Citron	.726	Olive-tree	.927
Cocoa-wood	1.040	Orange-tree	.705
Cherry-tree	.715	Pear-tree	.661
Cork	.240	Pomegranate-tree	1.354
Cypress, Spanish	.644	Poplar	.383
Ebony, American	.331	———, white, Spanish	.529
——— Indian	1.209	Plum-tree	.785
Elder-tree	.695	Quince-tree	.705
Elm, trunk of	.671	Sassafras	.482
Filbert-tree	.600	Vine	1.327
Fir, male	.550	Walnut	.671
—— female	.498	Willow	.585
Hazel	.600	Yew, Dutch	.788
Jasmin, Spanish	.770	—— Spanish	.807

GASES.

Atmospheric air (being)	1.0000	Fluo-silicic acid gas	3.5735
Vapour of hydriodic ether	5.4749	Vapour of sulphuret of	
——— oil of turpentine	5.0130	carbon	2.6447
Hydriodic acid gas	4.4430	——— sulphuric ether	2·5860

Chlorine	2.4700	Nitrous gas	1.0288
Fluo-boric gas	2.3709	Olefiant gas	0.9784
Vapour of muriatic ether	2.2190	Azote, or nitrogen gas	0.9691
Sulphurous acid gas	2.1920	Oxide of Carbon	0.9569
Cyanogen	1.8064	Hydro-cyanic vapour	0.9476
Vapour of absolute alcohol	1.6133	Phosphuretted hydrogen	0.8700
Nitrous oxide	1·5204	Steam of Water	0.6235
Carbonic acid	1.5196	Ammoniacal gas	0.5967
Muriatic acid gas	1.2474	Carburetted hydrogen	0.5550
Sulphuretted hydrogen	1.1912	Arseniated hydrogen	0.5290
Oxygen gas	1.1036	Hydrogen gas	0.0732

In this table the weights and specific gravities of the principal gases are given, as they correspond to a state of the barometer and thermometer which may be chosen for a medium. The specific gravity of any one gas to that of another, will not conform to exactly the same ratio, under different degrees of heat and other pressures of the atmosphere; because the various expansions by no means follow the same law.

These numbers being the weight of a cubic foot, or 1728 cubic inches, of each of the bodies, in avoirdupois ounces; by proportion, the quantity in any other weight, or the weight of any other quantity, may be readily known.

For example. Required the content of an irregular block of millstone, which weighs 1 cwt. or 112 lb. or 1792 ounces. Here, as 8500 : 1792 :: 1728 : $1228\frac{4}{5}$ cubic inches the content.

Ex. 2. To find the weight of a block of granite, whose length is 63 feet, and breadth and thickness, each 12 feet; being the dimensions of one of the stones of granite in the walls of Balbec. Here 63 × 12 × 12=9072 feet is the content of the stone; therefore as 1 : 9072 :: 3500 oz. : 31752000 oz. or 885 tons, 18 cwt. the weight of the stone.

To ascertain the purity of tin &c, pewterers, and other dealers in tin, cast a bullet of pure tin, and another of the mixture of tin and lead, which they want to examine, in the same mould; and the more the bullet of the mixture exceeds the bullet of pure tin, in weight, the more lead they conclude it contains.

DCCLXIV.

DEMONSTRATION OF THE SPECIFIC GRAVITY OF *Different Liquids.*

If we pour four liquors of different specific gravities into a glass vessel, they will remain separate and distinct from each other.

Thus, if we take Mercury, Oil of Tartar, Alcohol, and Oil of Turpentine, shake them together in a glass, and let them settle a few minutes, each will return to its proper place; viz. the Mercury at the bottom, the Oil of Tartar next, then the Alcohol, and above all, the Oil of Turpentine.

DCCLXV.

ICE IS SPECIFICALLY LIGHTER THAN WATER

At most Temperatures.

Pour water of any temperature from 52°, to 212°, into a bason, and place on it a flat piece of Ice: it will float on the surface. This shews the specific gravity of the Ice to be less than that of water at any point between these numbers. This is owing to the expansion of Ice during crystallization.

DCCLXVI.

THE SPECIFIC GRAVITY OF CARBONIC ACID GAS

Is greater than that of common Air.

Fix a lighted taper at the bottom of a tumbler, and pour Carbonic Acid Gas from another jar upon it; by inverting the jar, as if some other fluid was to be poured from it. The gas will quickly find its way to the bottom, and the taper will be extinguished.

DCCLXVII.

PROOF THAT AIR IS A BODY POSSESSING GRAVITY.

Invert a clean dry glass tumbler over a hand bason nearly full of water, and when the whole of the rim is brought exactly parallel with the surface, plunge it perpendicularly downwards. It may now be observed, that the water has risen considerably, in the bason: this rising is owing to the displacement by the glass of a volume of water equal to its own bulk; consequently no water can be within the tumbler. For if the inverted tumbler were filled with water, of course no greater rise could be observed in the bason, than what would be caused by the solid bulk of the sides of the glass which were immersed in it. The reason, then, that no water ascends in the glass is, that previous to its immersion, it was filled with air, which pressing upon the water below, prevents its ascent. Another proof that no water has entered the glass, is, that the inside will be found quite dry.

Observation. This experiment may be rendered more interesting by inverting the tumbler over a piece of cork, or wood, floating on the surface of the water. Here, the cork, or wood, (instead of remaining on a level with the surface of the water external to the glass,) will be seen at the bottom of the bason. After the experiment is over, the upper surface of the cork, or wood, will be found quite dry.

THE DIVING-BELL.

It is upon this principle, that the invention, and uses of the diving-bell are founded. The diving-bell is most conveniently made in form of a truncated cone, the smaller base being closed, and the larger open. It is to be poised with lead; and so suspended, that the vessel may sink full of air, with its open basis downward, and, as nearly as may be, in a situation parallel to the horizon, so as to close with the surface of the water all at once. The diver sitting under this, sinks down with the included air to the depth desired; and if the cavity of the vessel can contain a tun of water, a single man may remain a full hour, without much inconvenience, at a depth of five or six fathoms. But the lower he goes, the included air contracts itself according to the weight of the water which compresses it; so that at thirty-three feet deep the bell becomes half full of water, the pressure of the incumbent water being then equal to that of the atmosphere: and at all other depths, the space occupied by the compressed air in the upper part of the bell, will be, to the under part of its capacity, filled with water. This condensed atmosphere being taken in with the breath, soon accommodates itself to the existing circumstances so as to have no ill effect, provided the bell is permitted to descend slowly. But the greatest inconvenience of this engine is, that the water entering it contracts the bulk of air into so small a compass, that it soon heats, and becomes unfit for respiration; so that there is a necessity for its being drawn up to be recruited; add to this the uncomfortable situation of the diver, who must be almost covered with water.

The sinking and raising of the diving-bell, invented by Dr. Halley, depending entirely on the people at the surface of the water, and being besides of considerable weight, so as to occasion much labour, with a risk of the breaking of the rope by which it was to be raised, to the sure destruction of those within; a diving-bell has been invented by Mr. Spalding, of Edinburgh, to remedy these defects; and to prevent the edges of the machine from being entangled by any rugged prominences of rock. His machine is of wood, suspended by ropes, and having leaden weights appended to it; by which the mouth of the bell is kept always parallel to the surface of the water; whether the machine, taken altogether, be lighter or heavier than an equal bulk of water. By these weights alone, however, the bell would not sink; another is therefore added, which can be lowered or raised at pleasure, by means of a rope passing over a pulley, and fastened to one of the sides of the bell. As the bell descends, this weight, hangs down a considerable way below the mouth of the bell. In case the edge of the bell is caught by any obstacle, the balance-weight is immediately lowered down, so that it may rest upon the bottom. By this means the bell is lightened, so that all danger of oversetting is removed: for being lighter, without the balance-weight, than an equal bulk of water; it is evident that the bell will rise as far as the length of the rope affixed to the balance-weight. This, therefore, serves as a kind of anchor to keep the bell at any particular depth which the divers may think necessary; or, by pulling it quite up, the descent may be continued to the very bottom.

By another very ingenious contrivance, Mr. Spalding has rendered it possible for the divers to raise the bell, with all the weight appending to it, even to the surface of the water, or to stop it at any particular depth, as they think proper; and thus they would still be safe, even though the rope designed for pulling up the bell should be broken.

For this purpose the bell is divided into two cavities, both made as tight as possible. Just above the second bottom are small slits in the sides of the bell; through which the water, entering as the bell descends, displaces the air originally contained in its cavity, which flies out at the upper orifice of a cock expressly fitted for that purpose. When this is done, the divers turn the handle which stops the cock; so that if any more air were to get into the cavity, it could no longer be discharged through the orifice, as before. If, therefore, the divers wish to raise themselves, they turn the cock, by which a communication is made between the upper and under cavities of the bell. The consequence is, that a quantity of air immediately enters the upper cavity, forces out a quantity of the water contained in it, and thus renders the bell lighter by the whole weight of the water which is displaced. Thus, if a certain quantity of air is admitted into the upper cavity, the bell will descend very slowly; if a greater quantity, it will neither ascend nor descend, but remain stationary; and, if a larger quantity of air be still admitted it will rise to the top. It should be observed, however, that the air which is thus let out into the upper cavity, must immediately be replaced from the air-barrel; and the air is to be let out very slowly, or the bell will rise to the top with so great a velocity, that the divers will be in danger of being shaken out of their seats. But by following these directions, every possible accident may be prevented, and persons may descend to very great depths, without the smallest apprehension of danger. The bell also becomes so easily manageable in the water, that it may be conducted from one place to another, by a small boat, with the greatest ease, and with perfect safety to those within.

The diving-bell, though of late years greatly improved, is by no means a recent invention. It was employed in the year 1688, to bring up wealth sunk in some of the ships belonging to the Spanish Invincible Armada, near the island of Mull, in Scotland.

DCCLXVIII.

ASCENSION OF FLUIDS IN VACUO, BY EXTERNAL *Atmospheric Pressure.*

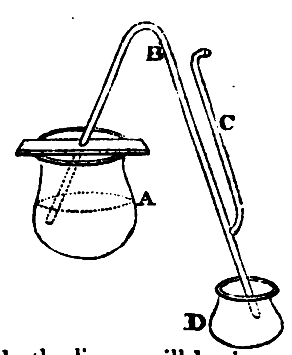
Put a small piece of burning Camphor; a piece of Phosphorus in a state of combustion, stuck on a cork; or a lighted paper, on the surface of water in a bason; and invert over it a tumbler, as in the last Experiment. The water instead of being displaced, will rush up into the glass, and will continue to do so, as long as the combustible substance remains burning.

Observations. In this case, a partial vacuum is formed by the decomposition of the atmospheric air, as it supports combustion; and the consequence is, that the air, external to the glass, pressing upon the water beneath with its accustomed force, causes it to ascend in the glass; there being no body present to resist the ascent. In this experiment the water, instead of ascending, will sink considerably in the bason; and upon inspection, the inside of the glass will be found quite wet: both circumstances exactly contrary to those in the last Experiment.

When the glass is raised *to* the surface of the water in the bason, that in the glass will not quit its place; the water below forming a support to the column above, by the pressure of the atmosphere. When the glass is raised *above* the surface of the water in the bason, a noise is produced by the ascent of the air and the rapid descent of the water; this is caused by the comparative levity of the one, and gravity of the other. There is an instrument in common use, called a valencia, for extracting small quantities of liquors out of the bung-holes of casks. It is a tube with a small aperture at the bottom, and at the top. When full, if the hole at the top is stopped with the thumb or finger, so as to prevent the pressure of the air at the top, the liquor will not run out of the hole at the bottom, being kept in by the force of the external air.

DCCLXIX.

CONSTRUCTION OF THE SYPHON.



The curious effects produced by syphons, depend entirely upon the pressure of the atmosphere. A syphon is a bent tube; (see B in the annexed figure,) made of glass, metal, &c. One branch of which is shorter than the other. In order to make use of this instrument, place the extremity of the short branch in the vessel A, which may be supposed to contain any fluid matter, as water for instance. If the air is then drawn out of the syphon by means of the long branch, the liquor will begin to flow, and will not cease, while the short branch remains immersed in the fluid. It is easy to see that the pressure of the air upon the surface of the fluid in the vessel, is the cause of its discharge through the syphon. For, all the points of the surface of the liquor A, will be equally pressed by the column of air; and, if, at some point of this surface, the pressure is suspended, the liquor must flow at that point, because it finds less resistance there, than in any other part; this is therefore the obvious reason why the syphon becomes full immediately after the air is drawn out at the extremity C.

If the two branches of the syphon were of equal lengths, the flow through the bent tube would not take place; because the column of air which would resist in D, being of an equal height with that which presses at A, would also be in equilibrium with it, in the same manner as the two columns of the fluid. But since one of the legs is longer than the other, it is not capable of preventing the passage of the fluid.

Since it is the pressure of the air which elevates the fluid in the short branch, it follows, that the height of this branch is limited to thirty-two feet, when the fluid is water; because the pressure of the atmosphere cannot elevate water higher: but when the liquor is mercury, the height of the short branch should not exceed thirty inches; because the atmosphere cannot sustain mercury at a greater height.

Observations. A syphon may be disguised in a cup, from which no liquor will flow, until it be raised above the bend of the syphon; but when the efflux once begins, it will continue to flow till the vessel be emptied. This has been called Tantalus's cup; because it is usual to place a hollow figure over the inner tube, of such a length, that when the fluid has got nearly up to the lips of the figure, the syphon may begin to act and empty the cup. Intermitting springs, which puzzled philosophers, formerly, are now found to be natural syphons.

DCCLXX.

FURTHER PROOF OF THE GRAVITY OF ATMOSPHERIC AIR.

Lay the palm of the hand on the open upper part of the receiver of an air-pump, and let the air be exhausted. As the air is pumped out, the hand will feel as if sucked into the receiver, and at last it will be found impossible to remove it. This is owing to the great weight of the column of air resting on the back of the hand, which presses it downwards into the vacuum. If, however, the air be gradually admitted by the stop-cock, the hand will be disengaged by degrees from the pressure which confines it, as the air fills the vacuum. Here the admission of the air restores the balance of pressure from beneath, and supports the hand, which otherwise must remain overburthened.

Observations. It is this pressure, by the gravity of the air, which prevents liquids from boiling, until a sufficient quantity of caloric be thrown into them to render them so elastic as to overcome that pressure. Experience proves that when this pressure has previously been removed, fluids boil at lower temperatures, than they do when that pressure is present. Water, for example, whose boiling point is 212°, boils at 88°, in vacuo. Water also, and ether, will evaporate much more quickly at the tops of high mountains, than they do in valleys.—To this atmospheric pressure, however, man owes his existence, for if he lived in vacuo, the fluids in his body, from the heat necessary for circulation, would have so great a tendency to evaporation, that their bounds would be destroyed, and the vessels which contained them would burst.

That water exists in the air has often been satisfactorily proved; and it has also been found impossible, totally to free it from moisture: this of course adds to its gravity, but it is, doubtless, more salubrious and fit for respiration, than it would be if completely dry. It has been ascertained that a cubic foot of atmospheric air is capable of holding eleven grains of water in solution.

THE BAROMETER.

In order to denote the occasional changes in the gravity of the atmosphere, the barometer has, for a long time, been in use; but the purpose to which the instrument is generally applied, is to ascertain the changes of the weather previous to their occurrence. It consists of a glass tube filled with mercury, to the height of thirty inches, with a vacuum above it; this tube is fixed in a case. When the air is charged with moisture, it is *heavier* than ordinary, and presses the mercury upwards; this is a sign of fair weather. When the vapours of the atmosphere are condensing, or about to do so, the air being *lighter*, does not press so much on the bulb of the barometer, consequently the mercury falls in the tube; this of course portends foul weather, such as snow, hail, &c. in winter, and rain in summer. When the mercury shifts frequently, the weather will be changeable. A small slide of brass is generally attached to these instruments, by moving which, the extent of change is ascertained, either when the mercury is above, or below it.

The barometer is founded on an experiment of Torricelli, who, considering that a column of water of about thirty-three feet was equal in weight to a column of air of the same base; concluded that a column of mercury, no longer than about twenty-nine inches and a half, would be so too, such a column of mercury being as heavy as thirty-three feet of water. Accordingly, he tried the experiment, and the apparatus he made use of is now the common barometer, or weather-glass.

DCCLXXI.

CONSTRUCTION OF BAROMETERS.

The tubes, of which Barometers are made, ought to be at least one fourth of an inch in bore; but one third, or even one half, of an inch is better. The tube should be new, and perfectly clean within; and that this may be the case, it should be hermetically sealed at both ends, at the glass-house, when made; one of the ends may be cut off with a file, when used. The Mercury ought to be perfectly pure, and should be freed from air by boiling it in a tube.

To fill the tube with Mercury, warm it, and pour some Mercury into it by a small paper funnel, so as to reach within an inch of the top; as the tube fills, bubbles of air will be observed in several parts. When the tube is full, apply the finger hard against the open end, and invert it; by which means, the open air that was on the top, now rising through all the quicksilver, gathers every bubble in its way. Turn the tube up again, and the bubble of air will re-ascend; if there are many small bubbles left, it will carry them away. If, however, any remain, the operation must be repeated. The tube is now to be filled to the top, and stopping the open end with the finger, must be inverted into a bason of Mercury. When the end of the tube is perfectly plunged under the surface of the Mercury, the finger must be taken away, and the Mercury in the tube will subside; remaining suspended at the height of 28 or 30 inches, according to the pressure of the atmosphere at the time. The space at the top of the tube is a perfect vacuum.

DCCLXXII.

ANOTHER METHOD.

The following is a still better way of filling the tube. Pour the purest Mercury into the tube (which must be very dry and well cleaned,) to within two inches of the top, and then hold it, with the sealed end lowest, in an inclined position, over a chaffing-dish of burning charcoal, placed near the edge of a table, in order that all parts of the tube may be exposed successively to the action of the fire, by moving it obliquely over the chaffing-dish. The sealed end is first to be gradually presented to the fire. As soon as the Mercury becomes hot, the internal surface of the tube will be studded with an infinite number of air-bubbles; giving the Mercury a kind of grey colour: these increase in size by running into one another, and ascend towards the higher parts of the tube, where, meeting with a cooler part of the fluid, they are condensed, and nearly disappear. In consequence, however, of successive emigrations towards the upper parts of the tube, which are successively heated, they finally acquire a bulk which enables them, in their united form, entirely to escape. When the first part of the tube is sufficiently heated, move it onward, by little and little, through its whole length. When the Mercury boils, its parts strike against each other, and against the sides of the tube, with such violence, that a person unacquainted with the operation, naturally apprehends the destruction of his tube. By this process, the Mercury is entirely deprived of the air which adhered to it.

The tube is now fixed with its bason to a wooden frame prepared for it, having a scale of inches at the upper end, which is accurately measured from the surface of the Mercury in the cistern.

This is the common construction of the Barometer and is still found to be the best.

Observations. A Thermometer should always be attached to the Barometer, as a necessary appendage; and by the side of it a scale of correction, to shew how much to add, or subtract, from the height of the mercury in the barometer for the degree of temperature: for it is evident that the mercury in the tube will be affected by heat and cold in the same manner as the thermometer; and on that account, it will not shew the true weight of the atmosphere. This correction is, therefore, very necessary.

Ever since it was observed that a change of weather generally accompanied, or followed, a variation in the height of the barometer, it has been used as a prognostic of the weather. A great variety of observations have been made by different people, relative to the effect which certain changes of weather have upon this instrument; and, thence they have derived a system of rules, to enable any one to know what change will happen in the weather, by knowing the alteration that has taken place in the height of the mercury.

Before we proceed to mention the rules, which are the result of the long observation and experience of philosophers, it is necessary to observe, that they are by no means so certain, and so much to be depended upon, as many people suppose. So numerous are the causes that affect the state of the atmosphere, with which we are but little acquainted, that no single instrument can point out, with precision, the alterations likely to happen. Besides the barometer, there are several other instruments used for meteorological purposes, such as the thermometer, hydrometer, wind-gage, rain-gage, electrometer, &c.*

As the barometer, however, is the most useful of these, and as it undoubtedly affords us considerable assistance, we shall lay down such directions as are most approved of for this purpose.

1. The rising of the mercury presages, in general, fair weather; and its falling, foul weather; as rain, snow, high winds, and storms. 2. In very hot weather, the falling of the mercury foretells thunder. 3. In winter, the rising pressages frost; and in frosty weather, if the mercury falls three or four divisions, there will certainly follow a thaw. But in a continued frost, if the mercury rises, it will certainly snow. 4. When foul weather happens soon after the falling of the mercury, expect but little of it: and, on the contrary, expect but little fair weather, when it proves fair shortly after the mercury has risen. 5. In foul weather, when the mercury rises much and high, and continues so for two or three days before the foul weather is quite over, then expect a continuance of fair weather to follow. 6. In fair weather, when the mercury falls much and low, and thus continues for two or three days before the rain comes, then expect a great deal of wet, and probably high winds. 7. The unsettled motion of the mercury denotes uncertain and changeable weather. 8. You are not so strictly to observe the words engraved on the plates (though in general it will agree with them), as the mercury's rising and falling; for if it stands at much rain, and

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* An instrument has lately been invented by Mr. Adie, of Dumfries, which answers as a common barometer, and has the advantage of being more portable, and less liable to accident. The moveable column is oil, enclosed in a tube with a portion of Nitrogen Gas, which changes its bulk according to the density of the atmosphere.

then rises up to changeable, it presages fair weather; though not to continue so long as if the mercury had risen higher: and, on the contrary, if the mercury stood at fair, and falls to changeable, it presages foul weather; though not so much of it, as if it had sunk lower.

From these observations it appears, that it is not so much the height of the mercury, in the tube, that indicates the weather, as the motion of it, up and down; wherefore, in order to form a right judgment of what weather is to be expected, we ought to know whether the mercury is actually rising or falling; to which end the following rules are of use:

1. If the surface of the mercury is convex, standing higher in the middle of the tube than at the sides, it is generally a sign that the mercury is then rising. 2. If the surface is concave, it is then sinking. And, 3, if it is level, the mercury is stationary; or rather, if it is a little convex; for mercury, being put into a glass tube, especially a small one, will naturally have its surface a little convex; because the particles of mercury cohere more forcibly, than they can be attracted by the glass. If the glass is small, shake the tube; and then if the air is grown heavier, the mercury will rise about the twentieth of an inch higher than it stood before; if it is grown lighter, it will sink as much. This proceeds from the mercury sticking to the sides of the tube, which prevents the free motion of it until it is disengaged by the shock; and therefore, when an observation is to be made by such a tube, it ought always to be shaken first; for sometimes the mercury will not vary of its own accord, until the weather it ought to have indicated, is present.

Here we must observe, that the above-mentioned phenomena are peculiar to places lying a considerable distance from the equator; for in the torrid zone, the mercury in the barometer seldom either rises or falls much. In Jamaica, it was observed by Sir William Beeston, that the mercury, in the morning, constantly stood at one degree below changeable, and at noon sunk to one degree above rain; so that the whole scale of variation there, was only three-tenths of an incn. At St. Helena, too, where Dr. Halley made his observations, he found the mercury to remain almost stationary, whatever weather happened. Of these phenomena, their causes, and why the barometer indicates an approaching change of weather, he gives us the following account.

1. In calm weather, when the air is inclined to rain, the mercury is commonly low. 2. In serene, good, and settled weather, the mercury is generally high. 3. In very violent winds, though they are not accompanied with rain, the mercury sinks lowest of all, with relation to the point of the compass the wind blows upon. 4. The greatest heights of the mercury are found upon easterly, or north-easterly, winds. 5. In calm frosty weather, the mercury generally stands high. 6. After very great storms of wind, when the mercury has been very low, it generally rises again very fast. 7. The more northerly places have greater alterations of the barometer, than the more southerly. 8. Within the tropics, and near them, according to the accounts we have had from others, and the observations made at St. Helena, the changes of the weather made very little, or no variation in the height of the mercury.

Hence, it is thought that the principal cause of the rise and fall of the mercury, is from the variable winds which are found in the temperate zone, and whose great inconstancy in England is notorious.

A second cause is, the uncertain exhalation and precipitation of the vapours lodging in the air, whereby it is at one time much more crowded than at another, and consequently heavier; but this latter depends in a great measure upon the former. Now, from these principles we may explain the several phenomena of the barometer, taking them in the same order as they are laid down. Thus,

1. The mercury being low, indicates rain; because the air being light, the vapours are no longer supported by it, having become specifically heavier than the medium in which they floated; so that they descend towards the earth, and, in their fall, meeting with other aqueous particles, they incorporate together, and form little drops of rain: but the mercury being at one time lower than another, is the effect of two contrary winds blowing from the place where the barometer stands; whereby the air of that place is carried both ways from it, and consequently the incumbent cylinder of air is diminished, and accordingly the mercury sinks: as, for instance, if in the German Ocean it should blow a gale of westerly wind, and at the same time an easterly wind in the Irish Sea; or, if in France it should blow a northerly wind, and in Scotland a southerly; it must be granted, that, that part of the atmosphere impendent over England would be exhausted and attenuated, and the mercury would subside, and the vapours which before floated in these parts of the air, of equal gravity with themselves, would sink to the earth.

2. The greater height of the barometer is occasioned by two contrary winds blowing towards the place of observation, by which the air of other places is brought thither and accumulated; so that the incumbent cylinder of air being increased both in height and weight, the mercury pressed by it must needs stand high, as long as the winds continue so to blow: and then the air being specifically heavier, the vapours are kept suspended, so that they have no inclination to precipitate, and fall down in drops; which is the reason of the serene good weather which attends the greater heights of the mercury.

3. The mercury sinks the lowest of all, by the very rapid motion of the air in storms of wind. For, the tract or region of the earth's surface, in which the winds rage, not extending all round the globe, that stagnant air which is left behind, as likewise that on the sides, cannot come in so fast as to supply the vacuity made by so swift a current: so that the air must necessarily be attenuated when, and where, the winds continue to blow; and that more or less, according to their violence. Add to this, that the horizontal motion of the air being so quick, may in all probability take off some part of the perpendicular pressure; and the great agitation of its particles is the reason why the vapours are dissipated, and do not condense into drops, so as to form rain; otherwise the natural consequence of the air's rarefaction.

4. The mercury stands highest in the easterly and north-easterly wind; because, in the great Atlantic Ocean, on this side the thirty-fifth degree of north latitude, the winds are almost always westerly or south-westerly; so that, whenever, here, the wind comes up at east and north-east, it is sure to be checked by a contrary gale as soon as it reaches the ocean; wherefore, according to the second remark, the air must needs be heaped over this island, and consequently the mercury must stand high, as often as these winds blow. This holds true in this country; but is not a general rule for others, where the winds are under different circumstances: and we have sometimes had the mercury here so low as 29 inches, upon an easterly wind; but then it blew exceedingly

hard; and, thus is accounted for what was observed in the third remark.

5. In calm frosty weather, the mercury generally stands high, because it seldom freezes but when the winds come out of the northern and north-eastern quarters, or at least, unless those winds blow at no great distance off; for the northern parts of Germany, Denmark, Sweden, Norway, and all that tract whence north-eastern winds come, are subject to almost continual frost throughout the winter: and thereby the air is very much condensed, and in that state is brought hitherward by those winds; and being accumulated by the opposition of the westerly wind blowing on the ocean, the mercury must needs be forced to a more than ordinary height. As a concurring cause, the shrinking of the lower parts of the air into lesser room, by cold, must cause a descent of the upper parts of the atmosphere, to reduce the cavity made by this contraction to an equilibrium.

6. After great storms, when the mercury has been very low, it generally rises again very fast. It has been observed to rise one inch and a half in less than six hours, after a long-continued storm of south-west wind. The reason is, that the air being very much rarefied by the great evacuation which such continued storms make of that fluid, the neighbouring air runs in, the more swiftly, to bring it into an equilibrium.

Lastly. The variations are greater in the more northerly places.

DCCLXXIII.

CONSTRUCTION OF HYGROMETERS.

The Hygrometer is an instrument to measure the degrees of drynses, or moisture, of the atmosphere.

There are divers sorts of Hygrometers; for whatever body either swells or shrinks, by dryness or moisture, is capable of being formed into an Hygrometer. Such are woods of most kinds, particularly ash, deal, poplar, &c. Such also is catgut, the beard of the wild oat, &c. The following is the most lasting, and convenient mode of constructing an instrument of this kind. Take a very nice balance, and place in it a sponge, or other body, which easily imbibes moisture; and let it be in equilibrio, with a weight hung at the other end of the beam. Now if the air become moist, the sponge becoming heavier, will preponderate; if dry, the sponge will be raised up. This balance may be contrived two ways; by either having the pin in the middle of the beam, with a slender tongue, a foot and a half long, pointing to the divisions on an arched plate fitted to it; or, the other extremity of the beam may be made so long, as to describe a large arch on a board placed for the purpose, as it is represented in the figure.

To prepare the sponge, it may be necessary to wash it in water; and when dry, in water or vinegar, in which sal-ammoniac, or salt of tartar, has been dissolved; and let it dry again: then it is fit to be used.

DCCLXXIV.

CONGELATION OF WATER, BY THE REMOVAL OF *Atmospheric Pressure.*

The cold excited by evaporation, aided by the process of absorption, as has been noticed in Page 78, may be prodigiously augmented, by combining with it the *operation of an Air Pump.* It appears, that air which is dilated, allowed to occupy a wider space, or, which possesses less Specific Gravity, becomes capable of holding a more than ordinary share of moisture. Such thin air, if kept at a state of dryness by the action of some absorbent substance, will therefore maintain a profuse evaporation, and occasion, of course, the production of most intense cold.

It is only required to place a porous cup containing water near a broad layer of sulphuric acid, within a perfectly close receiver, and to extract the greater part of the included air. The rare medium, which is left to occupy the internal space, greedily attracts the vapour which exhales from the humid surface, but again surrenders it, in its liquid form, to the acid. An incessant circulation is thus supported between the water and the acid, and successive portions of heat are abstracted continually, and transferred by the agency of the rare medium, from the steaming, to the absorbing surface. The water grows constantly colder, till it begins to shoot into ice; and after this congelation has taken place, the ice itself would become still colder, till it reached a certain limit of temperature: after which it would insensibly waste away by evaporation, and disappear entirely in the space of a few days.

Observations and Directions. Screw the plates of the air-pump firmly into their respective places, having previously rubbed their leathern collars with hog's lard. Unscrew the finger-screw, and pour in a table-spoonful of olive oil, whilst an assistant raises the piston in the barrel of the pump, by means of a lever. In this way the oil will be drawn up through all the valves; and let the process be repeated till it rises to the top of the barrel.

With the lever-key, screw on the gauge quite fast, observing that the leather is on the shoulder. The pump is now fit for action.

Place the glass saucers (see Plate 8,) on the brass plates, and pour on sulphuric acid, to the height of about half an inch. In the centre of the acid, set the stands, and adapt their basons: these stands consist of tin rings with slender glass feet, and are so low, that the bottom of each bason should come to within three quarters of an inch from the surface of the acid. Fill these cups to near the lips with pure water; and having rubbed the ground rims of the receivers with hog's lard or grease, apply them to the brass plates, giving them a slight turn to make them stick closer, and pass the finger with a little grease round the outside of the joint.

Now shut the stop-cocks, cutting off the mutual communication between the receivers, and proceed to work the pump. After two or three strokes, the mercury will be seen to sink in the gauge: continue the operation till the difference between the two opposite columns is only half an inch, if spring or well water be used; or push the exhaustion at once as far as, under such circumstances, it will go; or to about three-tenths of an inch, if the water used be fresh distilled, or recently boiled, and kept close shut up. Crude water discharges such a quantity of air when the rarefaction advances, as to assume an appearance of boiling, and sometimes of violent agitation; in which case, to prevent the accident of any part of the water being thrown over into the acid, it may be proper to intermit the pumping for a minute. Soon after the exhaustion is performed, the water will begin to freeze; during which process, new portions of air will be continually evolved, till, in the space of about half an hour, the ice becomes entirely consolidated. Now, open the cock, and re-admit the air; lift up the receiver carefully, and remove the frozen cup.

The same process is repeated with each receiver in succession; and after the exhaustion of the last one is completed, it may be sufficient time to take out the ice from the first, and to renew the circle of operations. When the sulphuric acid has become sensibly weakened by a course of long and repeated absorption, during which it may have acquired one-third of its weight of moisture, and effected the formation of perhaps five times its bulk of ice; it should be decanted off, and replaced by fresh concentrated acid.

DCCLXXV.

NEW METHOD OF CONGEALING WATER, DURING THE *Absence of Atmospheric Pressure.*

The beautiful discovery of Professor Leslie, on the artificial congelation of water, has successively engaged the attention of many learned philosophers and chemists. They have sought to give to this discovery a more extended application, in order to convert it to some great object of utility; and, already, their labours have led to some particular results, which might, otherwise, have remained long unattained.

M. T. Grothus gives the following account of his interesting experiment on this subject: "Into a metal vase half filled with water, I poured very gently an equal quantity of Ether, so that no mixture might take place in the two liquids. The vase was placed under the receiver of an air-pump, which was so fixed upon its support, as to remain quite steady when the air was pumped out. At the first stroke of the piston, the Ether became in a state of ebullition; it was evaporated totally in less than a minute, and the water remained converted into ice. I made this experiment for the first time at Mittau, in an apartment the temperature of which was 16° R."

DCCLXXVI.

Atmospheric Gravity acts equally,

Upon Light and Heavy bodies.

M. Benedict Prevost has devised the following simple experiment, for shewing that the retardation in the fall of light bodies is owing, *solely*, to the resistance of the air.—Place a piece of thin paper on the bottom of a small box, of such a weight, that in falling, the bottom will always keep lowermost, and having let fall the box and the paper from the height of two or three yards above a cushion, they will both reach it at the same time; while a piece of paper of the same size let fall at the same time, will flutter slowly and obliquely to the ground. The experiment will succeed if the paper is placed on a crown, or half-crown piece, without using a box.

DCCLXXVII.

Proof of the existence of Air in Water.

Pour some river, or spring water, into a Florence flask; set it over a lamp, and observe the globules of air which arise before the water boils: these consist of atmospheric air which is always combined with water; and which gives water that bland, pleasant taste, so different from that of distilled water:—the air being rarefied by heat, becomes so light as to ascend in quantities to the surface; where it bursts in the globular form.

DCCLXXVIII.

Proof that Ice contains Air.

Fasten a small piece of Ice to a pistol bullet, and immerse it in a vessel of hot water:—the Ice, otherwise lighter than water, would *float* in it without this additional weight. Presently, globules will be seen to arise in the vessel, and to burst the instant they arrive at the surface. Here, as the Ice melts, the air, formerly confined, will now be liberated; and being lighter than water, they ascend above it, to mix with the atmosphere. Ice is specifically lighter than water, because during its expansion by crystallization, the atmospheric air occupies the cells interposed between its crystals.

DCCLXXIX.

Comparative Levity of Heated Air.

In proportion as hot air flies upwards, the cold air flows around from all sides, to replace and balance the atmosphere. This fact may be proved by holding a candle at the bottom of the door, in a room where a fire burns—the cold air will drive the flame inwards. At the middle of the door, the flame will be stationary; but near the top of the door, the heated air will turn the flame outwards, whilst escaping from the cieling of the apartment.

Observations. On this principle, Van Marum discovered a very simple method of preserving the air pure, in large halls, theatres, and hospitals. The apparatus, for this purpose, is merely a common lamp, made according to Argand's construction, suspended from the roof of the building, and kept burning under a funnel, the tube of which rises above the roof without, and is furnished with a ventilator. For his first experiment, he filled his large laboratory with the smoke of oak shavings, and in a few minutes after, lighted his lamp; the whole smoke disappeared, and the chamber was perfectly purified.

Covent Garden Theatre is ventilated on this principle; and doubtless, the health of workmen in manufactories, would be highly benefited by the adoption of similar methods.

On the same principle, as the above, is supposed to be founded the non-freezing peculiarity of the waters of Loch Ness, in Scotland.

When any substance possesses a greater quantity of caloric than the substance in contact with it, the super-abundant portion has a tendency to pass from the former to the latter. Now the uppermost lamina of water in Loch Ness, being in contact with the incumbent colder air, experiences an abstraction of caloric; which, by increasing its specific gravity, causes it to descend; and a warmer lamina, of consequence, occupies its place. This lamina, in its turn, undergoes a similar process, and is succeeded by another; and so on. A circulation, if the frost be of sufficient continuance, thus proceeds, till the whole mass is reduced to the temperature of about 42° on Fahrenheit's thermometer. After it has arrived at this term, the circulation ceases; for then, a further abstraction of caloric produces, instead of a contraction, an expansion, of volume. The temperature of greatest density is, therefore, about 42°; and congelation, as is well known, takes place at 32°.

Hence it appears, that the circumstance under consideration is not peculiar to Loch Ness only; but to all lakes which, like that, are in some parts unfathomable; or, at least, so deep, that the circulation is kept up during the continuance of the frost.

The comparative warmth of the blue vapour, which, during the extremest cold of winter, hovers over the lake, is supposed to arise from the caloric imparted to it from the water.

DCCLXXX.

Levity of Hydrogen Gas shewn

By Inflating a Small Balloon.

The levity of this gas, may be demonstrated by making a balloon of gold-beater's skin, (using a little diluted gum-arabic to close up any holes or fissures,) filling it from a bladder or jar, and tying a thread round the mouth of it to prevent the escape of the gas. When fully blown, attach a fanciful car of coloured paper, or very thin paste-board, to it; and let it float in a large room; it will soon gain the cieling, where it will remain for any length of time. If this balloon is let off in the open air, the operator will not see it again. This experiment may be varied, by putting small grains of shot into the car, in order to ascertain (as well as the circumstances will permit,) the difference between the weight of hydrogen gas and the same bulk of atmospheric air. It is with this gas that balloons, on a large scale, are filled.

DCCLXXXI.

Inflation of Balloons on a large scale.

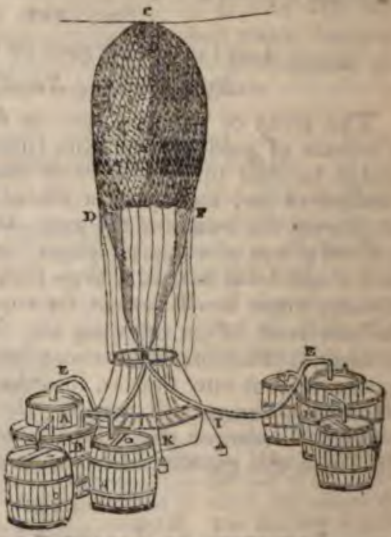
Iron, Zinc, Sulphuric Acid, and Water, are the ingredients generally used for the production of Hydrogen Gas, to inflate Balloons.

The Sulphuric Acid must be diluted with 5 or 6 parts of Water. Iron may be expected to yield in the common way 1700 times its own bulk of gas;—or 1 cubic foot of inflammable air may be produced by 4¼ ounces of Iron, the like weight of Sulphuric Acid, and 22½ ounces of Water. Six ounces of Zinc, an equal weight of Sulphuric Acid, and 30 ounces of Water are necessary for producing the same quantity of gas. It is more proper to use the turnings or chippings of great pieces of iron, as of cannon, &c., than the filings of that metal, because the heat attending the effervescence will be diminished; and the diluted acid will pass more readily through the interstices of the turnings when they are heaped together, than through the filings, which stick closer to one another.

The weight of the inflammable air, obtained, by means of Sulphuric Acid, is, in the common way of procuring it, generally one seventh of the weight of common air.

The annexed cut represents a Balloon filled from several vessels at one time.

A, A. are the inverted tubs which serve as Gasometers. B, B. are larger vessels containing water, through which the Hydrogen Gas passes to enter the Gasometer. This water preserves the apparatus air-tight, and purifies the Gas. C. is the base of the Balloon. D, F. represent network thrown over the Balloon, to which the car K, is fastened by means of cords. E, E. are the tubes which convey the Gas from Gasometers into the Balloon.



When a Balloon is to be filled, nothing more is necessary than to pour the diluted acid over the iron turnings in earthen vessels, each having one passage for the Gas to the Balloon, and another for receiving the ingredients. When only a little Hydrogen is evolved, the ingredients may be stirred with an iron rod. The ingredients may be passed into the vessels through glass funnels, and the passages should be corked whilst the Gas is forming; which may be conveyed by tin tubes to the Balloon.

Observations. The art of flying, or of imitating the feathered tribe, has long been the object of earnest desire amongst men. Cars, artificial birds, wings, and other pieces of mechanism for flying, generally absurd, and always insufficient, have frequently been exhibited to the undistinguishing eye of the vulgar; but the strictest enquiry into the accounts of authentic history, finds no mention of any success having ever attended attempts of this nature previous to the year 1782. The discoveries made on the nature and properties of the aerial fluids, by the industry of Black, Priestley, Cavendish, and others, suggested, some time before the above-mentioned year, the practicability of forming machines sufficient to elevate considerable weights into the regions of the atmosphere. Mr. Cavendish was the first who ascertained the specific gravity of hydrogen gas (then called inflammable air), and who found it to be much lighter than common air. His experiments on this subject are published in the Philosophical Transactions for the year 1766. In consequence of the discovery, it was natural to conclude, that if a large bladder, or other envelope, was filled with hydrogen gas, and that if the weight of the envelope added to that of the contained gas, was less than the weight of an equal bulk of common air; the apparatus would mount up into the atmosphere for the same reason, and in the same manner, as cork would rise from the bottom towards the surface of the sea.

Dr. Black, of Edinburgh, thought of filling the allantois of a calf with hydrogen gas, for the purpose of shewing at his lectures that such a body would ascend in the atmosphere; but he never put the project to the test of actual experience.

Early in the year 1782, M. Cavallo made the first attempt to elevate a bag full of hydrogen gas into the surrounding air; and an account of his experiments was read at a meeting of the Royal Society, on the 20th of June, 1782. He tried bladders, the thinnest and largest that could be procured. Some of them were cleaned with great care, removing from them all the superfluous membranes that could possibly be scraped off; but notwithstanding all these precautions, he found the largest and lightest bladders to be somewhat too heavy for the purpose. Some swimming-bladders of fishes were also found too heavy for the experiment; nor could he even succeed in making durable light balls by blowing hydrogen gas into a thick solution of gums, thick varnishes, and oil paint. In short, soap-balls, inflated with hydrogen gas, were the only things of this sort which could be elevated in the air. These, perhaps, were the first air-balloons that were ever constructed.

Not long after this, success attended an experiment of a similar nature made at Avignon, by Stephen Montgolfier: but the bag was not filled with hydrogen gas. It was filled with air rarefied by heat, which, of course, was lighter than an equal bulk of common air of the usual temperature.

It is said that the two brothers, Stephen and John Montgolfier, began to think on the experiment of the aerostatic machine, as early as the middle, or latter end, of the year 1782. The natural ascension of smoke, and of the clouds in the atmosphere, suggested the first idea; and to imitate those bodies, or to enclose a cloud in a bag, so that the latter might be elevated by the buoyancy of the former, was the first project of those celebrated gentlemen.

Stephen Montgolfier, the eldest, made the first aerostatic experiment at Avignon, towards the middle of November, 1782. The machine consisted of a bag of fine silk, in the shape of a parallelopipedon, open on one side, the capacity of which was equal to about 40 cubic feet. Burning paper, applied to its aperture, served to rarefy the air, or to form the cloud; and, when sufficiently expanded, the machine ascended rapidly to the cieling of the room. Thus, the original discovery was made, which was afterwards confirmed, improved, and diversified, by several persons, in different parts of the world.

As soon as the news of M. Montgolfier's successful experiment reached

Paris, the scientific persons of that capital, justly concluding that a similar experiment might be made, by filling a bag with hydrogen gas, immediately attempted to verify the supposition. A subscription for defraying the expences that might attend the accomplishment of the project, was immediately opened; persons of all ranks ran with eagerness to sign their names, and the necessary sum was speedily raised. Messieurs Roberts were appointed to construct the machine, and Mr. Charles, professor of experimental philosophy, was appointed to superintend the work.

The obstacles which opposed the accomplishment of this first attempt were many; but the two principal difficulties were to produce a large quantity of hydrogen gas, and to find a substance sufficiently light to make the bag of, and at the same time impermeable to the gas. At last they constructed a globular bag of a sort of silk stuff, called *lutestring;* which, in order to render it impervious to the gas, was covered with a certain varnish, said to consist of dissolved elastic gum. The diameter of this bag, which, from its ball-like shape, was called a *balloon*, was about 13 feet English. It had only one aperture, like the neck of a bladder, to which a stop-cock was adapted. The weight of the balloon, when empty, together with the stop-cock, was twenty-five pounds.

The attempts to fill this bag commenced on the 23d of August, 1783; but the operators met with so many difficulties and disappointments, from inadvertencies, want of materials, want of precaution, &c. that the actual ascent of the balloon, did not take place before the 26th of the same month. On the morning of that day, the inflated balloon, having a small cord fastened to its neck, was permitted to rise only to the height of about 100 feet; but at five o'clock in the afternoon of the 27th, it was disengaged from its fastenings, in the Champ de Mars, and rose majestically in the atmosphere, before the eyes of a great many thousand spectators, and amidst a copious shower of rain. In about two minutes time, it arose to the height of about 3123 feet. After remaining in the atmosphere only three-quarters of an hour, this balloon fell in a field near Gonesse, a village about fifteen miles from Paris. Its fall was attributed to a rupture that was found in it, and it was reasonably imagined, that the expansion of the hydrogen gas, when the balloon had reached a much less dense part of the atmosphere, had burst it. When this balloon went up, it was found upon trial to be thirty-five pounds lighter than an equal bulk of common air.

Thus, in the years 1782 and 1783, it was ascertained that bags full of hydrogen gas, or of rarefied common air, either of which is lighter than common air in its usual state, would ascend into the atmosphere, and that they might take up considerable weights.

Soon after the success of their first attempt, the Montgolfiers repeated the experiment in the open air, and with bags of different sizes; but their first grand and public exhibition in the presence of a numerous assembly, was made on the 5th of June, 1783, with an aerostatic machine or bag that measured thirty-five feet in diameter. The machine, inflated by the rarefied air, ascended to a considerable height, and then fell at the distance of 7668 feet from the original place of ascension. This experiment was described and recorded with great accuracy; and accounts of it were immediately forwarded to the court of France, to the Academy of Sciences, and almost as far as literary and entertaining correspondence could reach.

The younger Montgolfier, arriving at Paris not long after the above-mentioned public exhibition, was invited by the Academy of Sciences to repeat his singular aerostatic experiment; in consequence of which invitation, he began to construct an aerostatic machine of about seventy-two feet in height, at the expence of the academy. But while this operation was going on, and as a successful experiment with an inflammable air-balloon had already been performed on the 27th of August, the project of making balloons became general; and those who wished to make the experiment, on the smallest scale, soon calculated the necessary particulars, and found that the performance of the experiment was far from being either difficult or expensive. The baron de Beaumanoir, at Paris, was induced to try gold-beater's skin, and soon made a balloon, by gluing several pieces of that skin together. This balloon was no more than nineteen inches in diameter; it was of course easily filled with hydrogen gas; and on the 11th of September, 1783, it mounted with rapidity into the atmosphere.

M. Montgolfier, having completed his large balloon, agreeably to the desire of the academy, made a private experiment with it on the 11th of September, which succeeded. On the following day, another experiment was made with the same, before the commissaries of the academy, and a vast number of other spectators; but this experiment, in consequence of a violent shower of rain, was attended with partial success; and the aerostat was considerably damaged.

A similar machine was speedily constructed by the same M. Montgolfier, by whom the experiment was performed at Versailles, on the 19th of September, before the royal family of France, and an innumerable concourse of spectators. The preparations for filling the machine with rarefied air, consisted of an ample scaffold, raised some feet above the ground; in the middle of which there was a well or chimney, about sixteen feet in diameter; and in the lower part of which, near the ground, the fire was made. The aperture of the balloon was put round the chimney or well, and the rest of it was laid down over the well and the surrounding scaffold. As soon as the fire was lighted, the machine began to swell, acquired a convex form, stretched itself on every side; and in eleven minutes time, the cords being cut, the machine ascended, together with a wicker basket or cage, which was fastened to it by means of a rope; and in which a sheep, a cock, and a duck, had been placed. These were the first animals that ever ascended with an aerostatic machine. The apparatus rose to the height of about 1440 feet, and remained in the atmosphere during eight minutes; then fell at the distance of about 10,200 feet from Versailles, with the animals safe in the basket.

After the success of this experiment with the animals, &c. and when ten months had scarcely elapsed, since M. Montgolfier made his first experiment of this sort, M. Pilatre de Rozier publicly offered himself to be the first adventurer in the newly invented machine. His offer was accepted, his courage remained undaunted, and on the 15th of October, 1783, he actually ascended into the atmosphere, to the astonishment of a gazing multitude. The balloon with which he ascended was of an oval shape, its height being about seventy-four, and its horizontal diameter forty-eight feet. The aperture, or lower part of the machine, had a wicker gallery about three feet broad, with a ballustrade both within and without, about three feet high. The inner diameter of this gallery, and of the neck of the machine which passed through it, was nearly sixteen feet. In the middle of this aperture, an iron grate or brazier was supported by means of chains, which came down from the sides of the machine. In this construction, when the machine was up in the air, with a fire lighted in the grate, it was easy for a person who stood in the gallery, and had fuel with him, to keep up the fire in the opening of the machine, by throwing the fuel on the grate through port-holes made in the neck of the balloon; by which means, it might be kept up as long as the person in its gallery thought proper, or till he had no fuel to supply the fire with.

The first aerial voyage, with an inflammable air balloon, was performed on the 1st of December, 1783. Mr. Charles, and Mr. Robert, were the first adventurers. The balloon was globular, its diameter being twenty-seven and a half feet. A net went over the upper hemisphere, and was fastened to a hoop, which went round the middle of the balloon.—From this hoop ropes proceeded, and were fastened to a boat, which swung a few feet below the balloon. In order to prevent the bursting of the machine by the expansion of the gas in an elevated region, a valve was made in the upper part of it, which, by pulling a string, would open and let out part of the gas. There was likewise a long silken pipe, through which the balloon was filled.

The apparatus for filling it, consisted of several wooden casks placed round a large tub full of water, every one of which had a long tin tube, which terminated under a vessel or funnel, that was inverted into the water of the tub. A tube then proceeded from this funnel, and communicated with the balloon, which stood just over it. Iron filings and diluted sulphuric acid, were put into the casks; and the gas, which was extricated from those materials, passed through the tin tubes, then through the water of the tub, and, lastly, through the tube of the funnel into the balloon. See the Cut.

When Messieurs Charles and Robert placed themselves in the boat, they had with them proper philosophical instruments, provisions, clothing, and some bags full of sand, by way of ballast. With these preparations, they ascended at three-quarters after one o'clock. At the time they went up, the thermometer, (Fahrenheit's scale,) stood at 52 degrees, the mercury in the barometer stood at 27 inches, from which they deduced their altitude to be nearly 600 yards. During the rest of their voyage, the mercury in the barometer moved generally between 27 inches, and 27,65; rising and falling according as part of the ballast was thrown out, or some gas escaped from the balloon. The thermometer stood generally between 53° and 57.

Soon after their ascent they remained stationary for a short time; they then went horizontally, in the direction of N. N. W. They crossed the Seine, and passed over several towns and villages, to the great astonishment of the inhabitants, who did not expect to see such a spectacle, and who had perhaps never heard of this new sort of experiment. This charming aerial voyage lasted one hour and three quarters. At last they descended in a field near Nesle, a small town, about 27 miles distant from Paris; so that they had gone at the rate of about 15 miles per hour, without feeling the least inconvenience; and the balloon underwent no other alteration than what was occasioned by the dilatation and contraction of the gas, according to the vicissitudes of heat and cold.

The success of these experiments, spread an universal enthusiasm throughout Europe, and similar ones, both in the diminutive and in the large way, were soon undertaken in different countries. The first experiment of this kind, exhibited in London, was on the 25th of November, 1783, when an inflammable air balloon, 10 feet in diameter, was sent up by Count Zambeccari, an Italian gentleman. The first aerial voyage undertaken in England, with an inflammable air balloon of 33 feet in diameter, made of oil silk, was performed by M. Luardi, another Italian, on the 15th of September, 1784.

The abbe Bertholon seems to have been the first person who made use of small balloons for exploring the electricity of the atmosphere, which must be a very useful method, particularly in calm weather, when electrical kites cannot be raised. He raised several air balloons, to which long and slender wires were attached, the lower extremity of the wire being fastened to a glass stick or other insulated stand, whereby he obtained, from such wires, electricity enough to shew its kind, and even sparks.

On the 13th of January, 1784, an aerostatic machine, of about 37 feet in height, and 20 in diameter, was launched from the Castle De Bisancon, near Romano, in Dauphiny. It arose with surprising velocity, and as the wind was north, it went southward: but when the machine had ascended to the height of above 6000 feet. In less than ten minutes, it fell at the distance of nearly four miles.

This experiment, and indeed the similar success of many others, shews that there frequently are, in the atmosphere, currents of air in different, and sometimes quite opposite, directions; this, however, is far from being always the case. If different currents could always be met with at different heights above the surface of the earth, the method of guiding balloons would be extremely easy; for the aerial traveller would have nothing more to do than to place himself in the favourable current, which he might do by throwing out either some ballast or some inflammable gas, according as he wished to go higher or lower.

The largest aerostatic machine ever made, and filled with rarefied air, was launched at Lyons on the 19th of January, 1784, with not less than seven persons in its gallery, amongst whom were Joseph Montgolfier and Pilatre de Rozier. The height of this machine was about 113 feet, and its horizontal diameter about 104. Its weight, when it ascended, including passengers, gallery, &c. was about 1600 pounds.

This machine, having suffered considerably, in consequence of previous trials, was by no means in a perfect state when it ascended; nevertheless, when the action of the fire had inflated it, the seven persons, who in spite of every remonstrance, had placed themselves in the gallery, refusing to relinquish their places, the machine was released from the ropes, which confined it, and ascended majestically into the atmosphere. At a certain height, the wind turned it towards the west; but it afterwards proceeded east-south-east, ascending at the same time, until it was at least 1000 yards high.

The effect which was produced on the spectators by this spectacle, is described as the most extraordinary that was ever occasioned by any production of human invention. It was a mixture of the strangest nature imaginable. Vociferations of joy, shrieks of fear, expressions of applause, the sound of martial instruments, and the discharge of mortars, produced an effect more easily imagined than described. Some of the spectators fell on their knees, and others elevated their suppliant hands to the heavens; some women fainted, and many wept; but the confident travellers, without shewing the least appearance of fear, were continually waving their hats out of the gallery.

At about fifteen minutes after the ascent, the wind shifted again; but it was so feeble that the machine stood almost stationary for about four minutes. Unfortunately, about this time, a rent was made in the machine, which occasioned its descent; and when it came within 600 feet of the ground, its velocity was considerably accelerated. It is said that no less than 60,000 persons besides the Marechausee, ran to the spot, with the greatest apprehension for the lives of the adventurous aerial travellers. They were immediately helped out of the gallery, and luckily no person had received any hurt. The machine was torn in several places, besides a vertical rent of upwards of 50 feet in length, which clearly shews how little danger is to be apprehended from the use of those machines, especially when they are properly constructed and judiciously managed.

On the 5th of April, 1784, Messieurs de Morveau, and Bertrand, at Dijon, ascended with an inflammable air-balloon, which, according to their barometrical observations, seems to have reached the extraordinary height of 13,000 feet, when the cold was so great that the thermometer stood at 25°.

On the 15th of July, the duke de Chartres, the two brothers Roberts, and another person, ascended with an inflammable air-balloon, from the park of St. Cloud, at 52 minutes past seven in the morning. This balloon was of an oblong form, its dimensions being 55 feet by 34. It ascended with its greatest extension nearly horizontal; and after remaining in the atmosphere about 45 minutes, it descended at a small distance from its place of ascension. But the incidents that occurred during this aerial excursion deserve particular notice, as nothing like it had happened before, to any other aerial travellers. This machine contained an inferior small balloon, filled with common air; by which means it was supposed that they might regulate the ascent and the descent of the machine, without any loss of the hydrogen gas, or of ballast. The boat was furnished with a helm and oars, that were intended to guide the machine, but which were in this, as well as in every other similar attempt, found to be quite useless.

On the level of the sea, the mercury in the barometer stood at 30,25 inches, and at the place of ascension it stood at 30,12. Three minutes after its ascension, the balloon was lost in the clouds, and the aerial voyagers lost sight of the earth, being involved in a dense vapour. Here an unusual agitation of the air, somewhat like a whirlwind, in a moment turned the machine three times from the right to the left. The violent shocks which the adventurers suffered, prevented their using any of the means prepared for the direction of the machine; and they even tore away the silk stuff of which the helm was made. Never, said they, a more dreadful situation presented itself to any eye, than that in which they were involved. An unbounded ocean of shapeless clouds rolled beneath, and seemed to forbid their return to the earth, which was still invisible. The agitation of the balloon became greater every moment. They cut the cords which held the interior balloon, which consequently fell on the bottom of the external balloon, just upon the aperture of the tube that went down to the boat, and stopped that communication. At this time, the thermometer was a little above 44°. A gust of wind from below drove the balloon upwards, to the extremity of the vapour, where the appearance of the sun shewed them the existence of nature; but now, both the heat of the sun, and the diminished density of the atmosphere, occasioned such a dilatation of the gas that the bursting of the balloon was apprehended; to avoid which, they introduced a stick through the tube, and endeavoured to remove the inner balloon, which stopped the aperture within the external balloon; but the dilatation of the gas pressed the inner balloon so forcibly against that aperture, as to render every attempt ineffectual. During this time, they continually ascended, until the mercury in the barometer stood not higher than 24,36 inches; which shewed their height above the surface of the earth to be about 5100 feet. Under these dreadful circumstances, they thought it necessary to make a hole in the balloon, in order to give exit to the gas; and accordingly the Duke, himself, with one of the spears of the banners, made two holes in the balloon, which opened a rent of about seven or eight feet. In consequence of this, they then descended rapidly, seeing, at first, no object either on earth or in the heavens; but in a moment after, they discovered the fields, and that they were descending straight into a lake, wherein they would inevitably have fallen, had they not quickly thrown over about 60 pounds weight of ballast, which occasioned their coming down at about 30 feet beyond the edge of the lake. Notwithstanding this rapid descent, none of the four adventurers received any hurt; and it is remarkable, that out of six glass bottles, full of liquor, which were simply laid down in the boat, one only was found broken.

In the course of the summer, 1784, two persons, viz. one in Spain, and another near Philadelphia, in America, were very near losing their lives, by going up with rarefied air machines. The former, on the 5th of June, was scorched by the machine taking fire, and was hurt by the subsequent fall, so that his life was long despaired of. The latter, having ascended a few feet, was wafted by the wind against the wall of a house, and some part of the machinery was entangled under the eaves, from which he could not extricate it. At last, the great ascensional power of the machine broke the ropes and chains, and the man fell from the height of about 20 feet. The machine presently took fire, and was consumed.

The most remarkable aerial voyage that was ever made with an aerostatic machine, was the crossing of the English channel in an inflammable air balloon of 27 feet diameter. One of the adventurers in this dangerous voyage was M. Blanchard, an intrepid Frenchman, who had already made five aerial voyages with the very same balloon, both in France and in England.

On Friday the 7th of January 1785, being a fine clear morning, after a sharp frosty night, and the wind being about N. N. W. though hardly perceptible, M. Blanchard accompanied by Dr. Jeffries, an American gentleman, departed from Dover castle, directing their course for the French coast. Previous to departure, the balloon, with the boat, containing the two travellers, several necessaries, and some bags of sand for ballast, were placed within two feet of the brink of the perpendicular cliff before the castle. At one o'clock the intrepid Blanchard desired the boat, &c. to be pushed off; but the weight being too great for the power of the balloon, they were obliged to throw out a considerable quantity of ballast; in consequence of which they at last rose gently and majestically, though making very little way, with only three bags of ballast, of ten pounds weight each. At a quarter after one o'clock, the barometer, which on the cliff stood at 29,7, was fallen to 27,3; and the weather proved fine and warm. Dr. Jeffries describes with rapture the prospect which at this time was before their eyes.

The country to the back of Dover, interspersed with towns and villages, of which they could count thirty-seven, made a beautiful appearance. On the other side, the breakers on the Goodwin Sands appeared formidable. Opon the whole, they enjoyed a view, perhaps, more extended and diversified than was ever beheld by mortal eye. The balloon was much distended, and at 50 minutes past one o'clock was descending, in consequence of which they were obliged to throw out one bag and a half of sand. They were at this time about one-third of the way from Dover, and had lost distinct sight of the castle. Not long after, finding that the balloon was descending very fast, all the remaining ballast was thrown over, also a parcel of books, in consequence of which the balloon rose again. They were now at about half-way. At a quarter past two o'clock the rising of the mercury, in the barometer, shewed that they were descending; in consequence of which the remaining books were thrown into the sea. At 25 minutes after two, they were at about 3-fourths of the way, and an enchanting view of the French coast appeared before their eyes; but the lower part of the balloon was colapsed, owing to the loss or condensation of the gas, and the machine was descending, which obliged them to throw over their provisions, the oars or wings of the boat, and other articles. "We threw away," said Dr. Jeffries, "our only bottle, which in its descent cast out a steam like smoke, with a rushing noise, and when it struck the water, we heard and felt the shock very perceptibly on our car and balloon." But the balloon still approaching the sea, they began to strip and cast away their clothes They even intended to fasten themselves to the cords and cut the boat away, as their last resource; but at this critical point, they had the satisfaction to observe that they were rising; their distance from the French shore, which they were approaching very fast, was about four miles. Fear was now vanishing apace; the French land shewed itself every instant more beautiful, more distinct, and more extended; Calais, and above 20 other towns and villages, were clearly distinguished. Exactly at three o'clock they passed over the high grounds about midway between Cape Blanc and Calais; and it is remarkable that the balloon at this time rose very fast, and made a magnificent arch; probably owing to the heat of the land, which rarified in some measure the hydrogen gas. At last they descended as low as the tops of the trees, in the forest of Guinnes, and opening the valve for the escape of the gas, they soon after descended safe to the ground, after having accomplished an enterprise which will probably be recorded to the remotest posterity.

The following is the melancholy account of an experiment which was attended by the death of two aerial adventurers, one of whom was M. de Rozier, the first person that ever ascended with an aerostatic machine.

M. Pilatre de Rozier, desirous of diversifying and improving the new method of travelling through the air, formed a plan of combining the two species of aerostatic machines, from which he expected to render their joint buoyancy more lasting, and of course more useful. His plan was to place an inflammable air balloon at top, and to affix to it, by means of ropes, a rarefied air balloon, so that a space of several feet might intervene between the two. The passenger, or passengers, were intended to take their places in the gallery of the lower machine, whence they could regulate the fire, and might, by a proper management of the fuel, elevate or depress the whole, without the necessity of losing any inflammable gas from the upper balloon.

Accordingly this plan was put in execution. The upper or inflammable air balloon was of varnished silk, lined with a fine membrane, like goldbeater's skin. The other balloon was of strong linen. On the 15th of June 1785, at seven o'clock in the morning, every thing being ready, M. Pilatre de Rozier, and a Mr. Romain, placed themselves in the gallery of the balloon, with plenty of fuel, instruments, and other necessary articles, and arose in the atmosphere. The machine seemed to take the best possible direction, but the wind being both feeble and shifting, they changed their direction two or three times; but when they were at a considerable height, and not above ¾ of a mile from the place of ascension, the machine appeared to be in flames, and presently the whole was precipitated down to the ground. The unfortunate adventurers were instantly killed, their bones disjointed and dreadfully mangled by the tremendous fall.

How the inflammable air took fire is variously conjectured; but it is natural to suppose, that the sparks of fire must have flown from the lower to the upper or inflammable air balloon. On the ground, the bag of the upper balloon was in a great measure burned or scorched; that of the lower was entire.

Omitting the various uninteresting, though not numerous aerial voyages undertaken in various parts of the world, during the 17 years subsequent to the above-mentioned dreadful accident, we shall add the account of two experiments since performed in England by M. Garnerin. The first of these is remarkable for the very great velocity of its motion; the second for the exhibition of a mode of leaving the balloon, and of descending with safety to the ground.

On the 30th of June 1802, the wind being strong though not impetuous, M. Garnerin, and another gentleman, ascended with an inflammable air balloon from Ranelagh-gardens on the south-west of London, between four and five o'clock in the afternoon; and in exactly three quarters of an hour they descended near the sea, at the distance of four miles from Colchester. The distance of that place from Ranelagh is sixty miles; therefore, they travelled at the astonishing rate of 80 miles per hour. It seems that the balloon had power enough to keep them up four or five hours longer, in which time they might have gone safe to the continent; but prudence induced them to descend when they discovered the sea not far off.

The singular experiment of ascending into the atmosphere with an inflammable air balloon, and of descending with a machine called a parachute, was performed by M. Garnerin on the 21st of September 1802. He ascended from St. George's Parade, North Audley-street, and descended safe into a field near the Small Pox Hospital at Pancras.

The balloon was of the usual sort, viz. of oiled silk, with a net, from which ropes proceeded, which terminated in, or were joined to, a single rope at a few feet below the balloon. To this rope the parachute was fastened in the following manner.

The reader may easily form to himself an idea of this parachute, by imagining a large umbrella of canvas of about 30 feet in diameter, but destitute of the ribs and handle. Several ropes of about 30 feet in length, which proceeded from the edge of the parachute, terminated in a common joining from which shorter ropes proceeded, to the extremities of which a circular basket was fastened; and in the basket M. Garnerin placed himself. Now, the single rope, which has been said above to proceed from the balloon, passed through a hole in the centre of the parachute, also through certain tin tubes, which were placed, one after the other, in the place of the handle, or stick, of an umbrella, and was lastly fastened to the basket; so that when the balloon was in the air, by cutting the end of this rope next to the basket, the parachute, with the basket, would be separated from the balloon; and, in falling downwards, would be naturally opened by the resistance of the air. The use of the tin tube was to let the rope slip off, with greater certainty, and to prevent its being entangled with any of the other ropes; also to keep the parachute at a distance from the basket.

The balloon began to be filled at about two o'clock. There were 36 casks filled with iron filings and diluted sulphuric acid, for the production of the hydrogen gas. These communicated with three other casks, or general receivers, to each of which was fixed a tube that emptied itself into the main tube attached to the balloon.

At six, the balloon being quite full of gas, and the parachute, &c. being attached to it, Mr. Garnerin placed himself in the basket, and ascended majestically amidst the acclamations of innumerable spectators. The weather was the clearest and pleasantest imaginable; the wind was gentle and about west by south; in consequence of which M. Garnerin went in the direction of about east by north. In about eight minutes time, the balloon and parachute had ascended to an immense height, and M. Garnerin, in the basket, could scarcely be perceived. While every spectator was contemplating the grand sight before them, M. Garnerin cut the rope, and in an instant he was separated from the balloon, trusting his safety to the parachute.

At first, viz. before the parachute opened, he fell with great velocity; but as soon as the parachute was expanded, which took place a few moments after, the descent became very gentle and gradual. In this descent a remarkable circumstance was observed, namely, that the parachute with the appendage of cords and basket, soon began to vibrate like the pendulum of a clock, and the vibrations were so great, that, more than once, the parachute and the basket with M. Garnerin, seemed to be on the same level, or quite horizontal; which appeared extremely dangerous: however, the extent of the vibrations diminished as he came pretty near the ground. On coming to the earth, M. Garnerin experienced some pretty strong shocks, and when he came out of the basket, he was much discomposed; but he soon recovered his spirits, and remained without any material hurt.

As soon as the parachute was separated from the balloon, the latter ascended with great rapidity; and, being of an oval form, turned itself with its longer axis into an horizontal position.

Coutel, captain of the aeronautic corps, in France, ascended with the *Entreprenant* balloon on the 26th of June, 1794, and conducted the wonderful and important service of reconnoitering the hostile armies at the battle of Fleurus, accompanied by one adjutant and a general. He ascended twice on that day, to observe, from an elevation of four hundred and forty yards, the position and manœuvres of the enemy. On each occasion he remained four hours in the air, and, by means of preconcerted signals with flags, carried on a correspondence with General Jourdan, the commander of the French army, which, in consequence, was victorious.

His intended ascent had been made known to the enemy, who, at the moment when the balloon began to take its flight, opened the fire of a battery against the aeronauts. The first volley was directed too low: one ball, nevertheless, passed between the balloon and the car, and so near to the former, that Coutel imagined it had struck it. When the subsequent discharges were made, the balloon had already reached such a degree of altitude, as to be beyond the reach of cannon shot, and the aeronauts saw the balls flying beneath the car. Arrived at their intended height, the observers, remote from danger, and undisturbed, viewed all the evolutions of the enemy, and, from the peaceful regions of the air, commanded a distinct and comprehensive prospect of two formidable armies engaged in the work of death!

Balloons are useful in ascertaining the direction and nature of winds, rains, thunder-storms, hail, snow, and all kinds of meteors; also the temperature and rarity of the air at various elevations. They also would be useful for tracing out correctly, on maps, the real figure of islands, seas, coasts, mountains, and even continents. For the relief of seamen, when a ship is in danger, a balloon of a large size would be an invaluable acquisition. Balloons might also be used in the conveyance of men, goods, and letters, from one place to another.

From the knowledge of the simple fact that hydrogen gas is lighter than atmospheric air, what may not man achieve!!

DCCLXXXII.

CONSTRUCTION OF BALLOONS.

The shape of the balloon is one of the first objects of consideration. As a sphere admits the greatest capacity under the least surface, the spherical figure, or that which approaches nearest to it, has been generally preferred. However, since bodies of this form oppose a great surface to the air, and, consequently, a greater obstruction to the action of the oar or wings, than those of some other form, it has been proposed to construct balloons of a conical or oblong figure, and to make them proceed, with their narrow end forward. Some have suggested the shape of a fish; others, that of a bird; but either the globular, or the egg-like shape, is, all things considered, certainly the best which can be adopted.

The bag or cover, of an inflammable-air balloon, is best made of the silk stuff called lustring, varnished over. But for a Montgolfier, or heated-air balloon, on account of its great size, linen cloth has been used, lined within or without with paper, and varnished. Small balloons are made either of varnished paper, or simply of paper unvarnished, or of gold-beater's skin, and such like light substances. The best way to make up the whole coating of the balloon, is by different pieces, or slips, joined lengthways from end to end, like the pieces composing the surface of a geographical globe, and contained between one meridian and another; or like the slices into which a melon is usually cut, and supposed to be spread out flat.

After providing the necessary quantity of the stuff, and each piece having been properly prepared with drying oil, let the corresponding edges be sewed together in such a manner as to leave about half, or three-quarters, of an inch of one piece, beyond the edge of the other; in order that this may, in a subsequent row of stitches, be turned over the latter, and both again sewed down together: by so doing, a considerable degree of strength is given to the whole bag at the seams, and the hazard of the gas escaping, is doubly prevented. Having gone in this manner through all the seams, the following method of M. Blanchard is admirably calculated to render them yet more perfectly air tight. The seam being doubly stitched, as above, lay beneath it a piece of brown paper, and also another piece over it on the outside; upon this latter, pass several times a common fire-iron, heated just sufficiently to soften the drying oil in the seam; this done, every interstice will be now closed, and the seams rendered completely air tight. The neck of the balloon being left a foot in diameter, and three in length, and all the seams finished, the bag will be ready to receive the varnish, a single coating of which on the outside is found preferable to the former method of giving an internal as well as an external coat.

The car, or boat, is best made of wicker-work, covered with leather, and painted; and the proper method of suspending it, is by ropes proceeding from the net which goes over the balloon. The net should be formed to the shape of the balloon, and fall down to the middle of it, with various cords proceeding from it to the circumference of a circle about two feet below the balloon; and from that circle other ropes should go to the edge of the boat. This circle may be made of wood, or of several pieces of slender cane bound together. The meshes of the net may be small at top, against which part of the balloon, the inflammable air exerts the greatest force; and increase in size as they recede from the top.

If a parachute is required, it should be constructed so, as, when distended, to form but a small segment of a sphere, and not a complete hemisphere; as the weight of this machine is otherwise considerably increased, without gaining much in the opposing surface. The parachute of M. Garnerin is particularly defective in the too great extension of its diameter; viz. by an unnecessary addition to its weight of a lining of paper, both withinside, and without; and in the too near approximation of the basket to the body of the parachute; but especially, in the want of a perpendicular cord passing from the car to the centre of the concave of the umbrella; by the absence of which, the velocity of the descent is certain to be very rapid before the machine becomes at all distended. Whereas, if a cord were thus disposed, the centre of the parachute would be the portion first drawn downwards by the appended weight, and the machine would be almost immediately at its full extension. Having found, by experiment, the diameter, required for insuring safety, the further the basket, or car, is from the umbrella, the less fear shall we have of an inversion of the whole from violent oscillations; yet, the longer the space between the car and the head of the machine, the longer will be the space run through, in each vibration, when once begun; still, by so much the more, will they be steadier. This ought to be attended to, as, when by the violence of the oscillations, the car became (in Garnerin's experiment) on a line with the horizontal axis of the machine; the gravitating power of the weight in the car, on the umbrella, being at that crisis reduced to nothing, the slightest cause might have carried the body of the machine in a lateral direction, reversing the concavity of the umbrella; and M. Garnerin, might, perhaps, have fallen upon the (now) convex, yet internal portion of the bag: consequently the whole would have descended confusedly together.

DCCLXXXIII.

COMPOSITION FOR VARNISHING BALLOONS.

The compositions for varnishing balloons have been variously modified; but, upon the whole, the most approved appears to be the bird-lime varnish of M. Faujas St. Fond, prepared after M. Cavallo's method, as follows: "In order to render linseed oil drying, boil it, with two ounces of sugar of lead, and three ounces of litharge, for every pint of oil, till they are dissolved, which may be in half an hour. Then put a pound of bird-lime, and half a pint of the drying oil into an iron or copper vessel, whose capacity should equal about a gallon, and let it boil very gently over a slow charcoal fire, till the bird-lime ceases to crackle, which will be in about half, or three-quarters, of an hour: then pour upon it two pints and a half more of the drying oil, and let it boil about an hour longer; stirring it frequently with an iron or wooden spatula. As the varnish, whilst boiling, and especially when nearly ready, swells very much, care should be taken to remove, in those cases, the pot from the fire, and to replace it when the varnish subsides; otherwise it will boil over. Whilst the stuff is boiling, the operator should occasionally examine, whether it has boiled enough; which may be known by observing whether, (when rubbed between two knives, which are then to be separated from one another,) the varnish forms threads between them, as it must then be removed from the fire: when nearly cool, add about an equal quantity of oil of turpentine. In using the varnish, the stuff must be stretched, and the varnish applied lukewarm: in twenty-four hours it will be dry."

DCCLXXXIV.

ANOTHER COMPOSITION.

As the elastic resin, known by the name of Indian rubber, has been much extolled for a varnish, the following method of making it, as practised by M. Blanchard, may not prove unacceptable.—Dissolve elastic Gum, cut small, in five times its weight of rectified essential Oil of Turpentine, by keeping them some days together; then boil one ounce of this solution in eight ounces of drying linseed oil for a few minutes; strain the solution, and use it warm.

DCCLXXXV.

VARNISH FOR RAREFIED AIR BALLOONS.

With regard to the rarefied-air machines, M. Cavallo recommends, first, to soak the cloth in a solution of sal-ammoniac and common size, using one pound of each to every gallon of water; and when the cloth is quite dry, to paint it over in the inside with some earthy colour, and strong size or glue. When this paint has dried perfectly, it will then be proper to varnish it with oily varnish, which might dry before it could penetrate quite through the cloth. Simple drying linseed oil will answer the purpose as well as any, provided it be not very fluid.

DCCLXXXVI.

INFLATION OF BALLOONS BY GAS, FROM COALS.

For obtaining inflammable air from pit-coal, asphaltum, amber, &c. &c. M. Cavallo recommends the following apparatus:—Let a vessel be made of clay, or rather of iron, in the shape of a Florence flask, somewhat larger, and whose neck is longer and larger. Put the substance, to be used, into this vessel, so as to fill about four-fifths, or less, of its cavity. If the substance be of such a nature as to swell much by the action of the fire, lute a tube of brass, or first a brass and then a leaden tube, to the neck of the vessel; and let the end of the tube be so shaped, that, going into the water, it may terminate under a sort of inverted vessel, to the upper aperture of which the balloon is adapted. Things thus prepared, if the part of the vessel is put into the fire, and made red-hot, the inflammable air, produced, will come out of the tube, and passing through the water will at last enter into the balloon.

Observation. Previous to the operation, as a considerably quantity of common air remains in the inverted vessel, which it is more proper to expel; the vessel should have a stop-cock, through which the common air may be sucked or pumped out, and the water will ascend as high as the stop-cock.

DCCLXXXVII.

HYDROGEN GAS PROCURED BY MEANS OF STEAM.

To procure inflammable air by means of Steam, Dr. Priestley used a tube of red-hot brass, which he filled with the turnings of iron that were separated in the boring of cannon. By this means he obtained an inflammable air, the specific gravity of which is to that of common air as 1 to 13. In this method, not yet indeed reduced to general practice, a tube about three-quarters of an inch in diameter, and about three feet long, is filled with iron-turnings; then the neck of a retort, or close boiler, half-filled with water, is luted to one of its ends, and the worm of a refrigeratory is adapted to its other extremity. The middle part of the tube is then surrounded with burning coals, so as to keep about one foot in length of it red-hot, and a fire is always made under the retort or boiler sufficient to make the water boil with vehemence. In this process a considerable quantity of inflammable air comes out of the refrigeratory. It is said that Iron yields one half more air by this method than by the action of Sulphuric Acid.

DCCLXXXVIII.

Inflation of Rarefied-Air Balloons.

With regard to the rarefied-air balloons, the method of filling them is by means of a scaffold, the breadth of which is at least two-thirds of the diameter of the machine, and elevated about six or eight feet from the ground. From the middle of it descends a well, rising about two or three feet above, and reaching to the ground, furnished with a door, through which the fire in the well is supplied with fuel. The well should be constructed of brick, and its diameter should be somewhat less than that of the machine. On each side of the scaffold are erected two masts, each of which is fixed by ropes, and has a pulley at the top. The machine is to be placed on the scaffold, with its neck round the aperture of the well. The rope passing over the pulleys of the two masts, serves to lift the balloon about fifteen feet above the scaffold; and it is kept steady, and held down, whilst filling, by ropes passing through loops or holes about its equator. These ropes may easily be disengaged from the machine, by slipping them through the loops when it is able to sustain itself. The proper combustibles, to be lighted in the well, are those which burn quick and clear, rather than such as produce much smoke; because it is *hot air*, and not smoke, that is required. Small wood, and chopped straw, are very fit for this purpose. As the current of hot air ascends, the machine will dilate, and lift itself above the scaffold and gallery which was covered by it. The passengers, fuel, instruments, &c. are then placed in the gallery. When the machine makes efforts to ascend, its aperture must be brought, by means of the ropes annexed to it, towards the side of the well, a little above the scaffold; the fire-place is then suspended in it, the fire lighted in the grate, and the lateral ropes being slipped off, the machine is let go.

Observations. It has been determined by accurate experiments, that only one-third of the common air can be expelled from these large machines; and therefore the ascending power of the rarefied-air in them, can be estimated as only equal to half an ounce avoirdupoise for every cubic foot.

The conduct of balloons when constructed, filled, and actually ascended in the atmosphere, is an object of great importance in the practice of aërostation. The method generally used for elevating or lowering the balloons with rarefied air, has been the increase or diminution of the fire; and this is entirely at the command of the aeronaut, as long as he has any fuel in the gallery. The inflammable-air balloons have been generally raised or lowered by diminishing their ballast, or by letting out some of the gas through the valve: but the alternate escape of the air in descending, and discharge of the ballast for ascending, will by degrees render the machine incapable of floating; for in the air it is impossible to supply the loss of ballast, and very difficult to supply that of inflammable air. These balloons will also rise or fall by means of the rarefaction or condensation of the inclosed air, occasioned by heat and cold, as has been already observed. Wings or oars are the only means of this sort that have been used with any probable success; and, as M. Cavallo observes, they seem to be capable of considerable improvement, though much is not to be expected from them, when the machine goes at a great rate. It is a matter of surprise, that the various hints for directing balloons appear to lie dormant with their projectors, who seem indisposed to make any attempts to carry their plans into execution: thus the inventions of professor Daniel, also of Martin, and the proposals for performing the same by means of eagles trained for the purpose; or by a reversed parachute, to retard the direct progress of the balloon, whereby less power will be necessary to impel it in a lateral direction;—all these plans remain obsolete and unpractised from the time of their suggestion.

With respect to the probability of directing aërostatic machines, we may infer it to be possible, although the methods hitherto tried have been inadequate; perhaps because they were not sufficiently powerful. To expect to make so large a body as a balloon to vary from the wind by the impulsion of an oar of six or eight feet in length, and one or two in breadth, (and that by only endeavouring to draw the car out of the perpendicular,) is to expect, by means of a boat's oar, to impel a ship of burthen. Oars are, doubtless, the most likely means to effect this purpose, if they were of dimensions proportionate to the effects they are wished to produce.

The addition of sails, where any variation from the wind is desired, will prove injurious, till we have attained a method (perhaps only to be accomplished by oars) of keeping the same point of the balloon continually in a given direction. Yet we doubt not but these also might prove of great service in quick dispatches, by water; as, for instance, where it is required to pass a fortress or fleet; for the succour of a besieged town, or to convey dispatches thereto. A small balloon, of ten or twelve feet in diameter, provided with sails to expose a large surface to the wind, being attached by a long rope to a boat, would outstrip the quickest vessel, and might also be made to deviate from the course of the wind; as the water would form a counter-resisting medium, the want of which in air-balloons occasions the difficulty in steering them, A sail-balloon, similar to the above, might also be advantageously attached to a land-carriage; namely, by increasing the capacity of the balloon, so that its power of ascension being nearly equal to the weight of the appended carriage, the latter would be drawn along by the impulsion of the wind against the balloon and sails; while the friction over the ground, by the small overplus weight, may be reasonably expected to afford a resistance sufficient to guide the machine, and allow of a deviation in the carriage of at least eight points from the course of the wind.

In addition to the uses, already mentioned, to which balloons are applicable, they might serve to expedite the communication of important events by signals, and serve for exploring, from a great elevation, adjacent coasts or regions, fleets, and armies. The French ascribe to the information obtained, in consequence of thus reconnoitering the army of the enemy, the signal victory gained in the battle of Fleurus, in 1794. Balloons may likewise serve to explore and ascertain the nature of the air in the highest regions of the atmosphere. One of the finest experiments made on this point is that of Gay-Lussac; who, being elevated in a balloon to the height of nearly eight miles, the greatest ever attained by any person, brought some atmospheric air from those regions, which, on being analysed, *was found to furnish oxygen, azote, hydrogen, and carbonic acid gas, in the same proportions as at the surface of the earth.* The application of these machines to the advancement of our knowledge of the various phenomena in meteorology stands, prominent; as, perhaps, the only means of maturing our acquaintance with causes yet known only by their effects. Their use will also be indicated in many urgent cases where other means of conveyance might fall short.

The, hitherto, unsuccessful attempts to render aërial navigation of service to mankind, ought to furnish no argument for causing it to be discouraged by men of sense, or prohibited by civil authority. Many arts and sciences from which commercial nations now derive so much benefit, were long in rearing to maturity; and were only at length produced for the public good, in consequence of patient investigation and reiterated experiments.

CHAPTER XVIII.

COLOURING AND BLEACHING.

Dyeing of Woollens, Linens, Silks, &c.

PERMANENT alterations in the colour of cloth can only be induced in two ways; either by producing a chemical change in the cloth, or by covering its fibres with some substance which possesses the wished for colour. Recourse can seldom, or never, be had to the first method, because it is hardly possible to produce a chemical change in the fibres of cloth, without spoiling its texture, and rendering it useless. The dyer, therefore, when he wishes to give a new colour to cloth, has always recourse to the second method.

The substances employed for this purpose are called colouring matters, or dye-stuffs. They are for the most part extracted from animal and vegetable substances, and have usually the colour, which they are to give to the cloth.

Since the particles of colouring matter with which cloth, when dyed, is covered, are transparent, it follows, that all the light reflected from dyed cloth must be reflected, not by the dye-stuff itself, but by the fibres of the cloth below the dye-stuff. The colour therefore does not depend upon the dye alone, but also upon the previous colour of the cloth. If the cloth is black, it is clear that we cannot dye it of any other colour whatever; because, as no light in that case is reflected, none can be transmitted, whatever dye-stuff we employ. If the cloth was red, or blue, or yellow, we could not dye it of any colour except black; because as only red, or blue, or yellow rays were reflected, no other could be transmitted. Hence the importance of *a fine white colour*, when cloth is to receive bright dyes. It then reflects all the rays in abundance; and therefore any colour may be given, by covering it with a dye-stuff which transmits only some particular rays.

If the colouring matters were merely spread over the surface of the fibres of cloth, by the dyer, the colours produced might be very bright, but they could not be permanent; because the colouring matter would be very soon rubbed off; and would totally disappear whenever the cloth was washed, or even barely exposed to the weather. The colouring matter then, however perfect a colour it possesses, is of no value, unless it also adheres so firmly to the cloth, that none of the substances usually applied to cloth, in order to clean it, &c. can displace it. Now, this can only happen, when there is a strong affinity between the colouring matter and the cloth, and when they are actually combined together, in consequence of that affinity.

Dyeing then is a chemical process, and consists in combining a certain colouring matter with fibres of cloth. This process can in no instance be performed, unless the dye-stuff is first reduced to its integrant particles; for the attraction of aggregation between the particles of dye-stuffs, is too great to be overcome by the affinity between them and the cloth, unless they could be brought within much smaller distances, than is possible while they both remain in a solid form. It is necessary, therefore, previously to dissolve the colouring matter in some liquid, which has a weaker affinity for it, than the cloth has. When the cloth is dipped into this solution, the colouring matter is brought within the attracting distance; the cloth therefore acts upon it, and from its stronger affinity, takes it from the solvent, and fixes it upon itself. By this contrivance too, the equality of the colour is, in some measure, secured; as every part of the cloth has an opportunity of attracting, to itself, the proper proportion of colouring particles.

The facility with which cloth imbibes a dye, depends upon two circumstances; namely, the affinity between the cloth and the dye-stuff, and the affinity between the dye-stuff and its solvent. It is directly as the former, and inversely as the latter. It is of importance to preserve a due proportion between these two affinities, as, upon that proportion much of the accuracy of dyeing depends. If the affinity between the colouring matter and the cloth is too great, compared with the affinity between the colouring matter and the solvent, the cloth will take the dye too rapidly, and it will be scarcely possible to prevent its colour from being unequal. On the other hand, if the affinity between the colouring matter and the solvent is too great, compared with that between the colouring matter and the cloth, the cloth will either not take the colour at all, or it will take it very slowly and very faintly.

Wool has the strongest affinity for almost all colouring matters, silk the next strongest, cotton a considerably weaker affinity, and linen the weakest affinity of all. In order therefore, to dye cotton or linen, the dye-stuff should, in many cases, be dissolved in a substance for which it has a weaker affinity, than for the solvent employed in the dyeing of wool or silk. Thus we may use Oxide of Iron dissolved in Sulphuric Acid, in order to dye wool; but for cotton and linen, it is better to dissolve it in Acetous Acid.

Was it possible to procure a sufficient number of colouring matters, having a strong affinity for cloth, to answer all the purposes of dyeing, that art would be exceedingly simple and easy. But this is by no means the case; for if we except Indigo, the dyer is scarcely possessed of a dye-stuff which yields, of itself, a good colour, sufficiently permanent to deserve the name of a dye.

This difficulty, which at first sight appears insurmountable, has been obviated by a very ingenious contrivance. Some substance is employed, which has a strong affinity, both for the cloth and for the colouring matter. This substance is previously combined with the cloth, which is then dipped into the solution containing the dye-stuff. The dye-stuff. combines with the intermediate substance, which, being firmly combined with the cloth, secures the permanence of the dye. Substances employed for this purpose are denominated *mordants*.

The most important part of dyeing, is undoubtedly the proper choice, and the proper application of *mordants*; as upon them, the permanency of almost every dye depends. Every thing which has been said respecting the application of colouring matters, applies equally to the application of mordants. They must be previously dissolved in some liquid, which has a weaker affinity for them than the cloth has, to which they are to be applied; and the cloth must be dipped, or even steeped in this solution, in order to saturate itself with the mordant.

Almost all the substances used as mordants, are earths, Metallic Oxides, Tan, and Oil.

Of earthy mordants, the most important, and most generally used, is Alumine. It is used either in the state of common alum, in which it is combined with Sulphuric acid, or in that of Acetite of Alumine.

Alum, when used as a mordant, is dissolved in water, and, very frequently, a quantity of Tartrate of Potass is dissolved along with it. Into this solution the cloth is put, and kept in it, till it has absorbed as much Alumine, as is necessary. It is then taken out, and for the most part washed and dried. It is now a good deal heavier than it was before, owing to the Alumine which has combined with it. The Tartar serves two purposes; the Potass which it contains, combines with the Sulphuric Acid of the alum, and thus prevents that very corrosive substance from injuring the texture of the cloth, which otherwise might happen: the Tartareous Acid, on the other hand, combines with part of the Alumine, and forms a Tartrate of Alumine, which is more easily decomposed by the the cloth, than alum.

Acetite of Alumine has been but lately introduced into dyeing. This mordant is prepared by pouring Acetate of Lead into a solution of alum; a double decomposition takes place, the Sulphureous acid combines with the Lead, and the compound precipitates in the form of an insoluble powder, whilst the Alumine combines with the Acetous Acid, and remains dissolved in the liquid. This mordant is employed for cotton and linen, which have a weaker affinity than wool for Alumine. It answers much better than alum; the cloth is more easily saturated with Alumine, and takes, in consequence, both a richer and more permanent colour.

Besides Alumine, Lime is sometimes used as a mordant. Cloth has a strong affinity for it; but, in general, it does not answer so well, as it does not give so good a colour. When used, it is in the state of Lime-water.

Almost all the metallic oxides have an affinity for cloth, but only two of them are extensively used as mordants, namely, the Oxides of Tin, and of Iron.

The Oxide of Tin was first introduced into dyeing by Kuster, a German chemist, who brought the secret to London in 1543. This period forms an era in the history of dyeing.

The Oxide of Tin has enabled the moderns greatly to surpass many of the ancients, in the fineness of their colours; and even to equal the famous Tyrian purple: by means of it alone, scarlet, the brightest of all colours, is produced.

Tin, as Proust has proved, is capable of two degrees of oxidation. The first Oxide is composed of 0.70 parts of Tin, and 0.30 of Oxygen; the second, or white oxide, of 0.60 parts of Tin, and 0.40 of Oxygen. The first Oxide absorbs Oxygen with very great facility, even from the air, and is rapidly converted into white Oxide. This fact makes it certain, that it is the white Oxide of Tin, alone, which is the *real* mordant: even if the other Oxide was applied to cloth, as it probably often is, it must soon be converted into white Oxide, by absorbing Oxygen from the atmosphere.

Tin is used as a mordant in three states: dissolved in Nitro-Muriatic Acid, in Acetous Acid, and in a mixture of Sulphuric and Muriatic Acids. Nitro-Muriate of Tin is the common mordant employed by dyers. They prepare it, by dissolving Tin in diluted Nitric Acid, to which a certain proportion of Muriate of Soda (common salt), or of Muriate of Ammonia (sal-ammoniac), is added. Part of the Nitric Acid decomposes these salts, combines with their bases, and sets the Muriatic Acid at liberty. It was prepared at first with Nitric Acid alone, but that mode was very defective, because the Nitric Acid very readily converts Tin to white Oxide, and then is incapable of dissolving it; the consequence of which was, the precipitation of the whole of the Tin. To remedy this defect, common salt, or sal-ammoniac, was very soon added; Muriatic Acid having the property of dissolving white Oxide of Tin very readily. A considerable saving of Nitric Acid might be made, by employing as much Sulphuric Acid, as is just sufficient to saturate the base of the common salt, or sal-ammoniac employed.

When the Nitro-muriate of Tin is to be used as a mordant, it is dissolved in a large quantity of water, and the cloth is dipped in the solution, and allowed to remain till sufficiently saturated. It is then taken out, and washed and dried. Tartar is usually dissolved in the water along with the Nitro-Muriate. The consequence of this is a double decomposition: the Nitro-muriatic Acid combines with the Potass of the Tartar, while the Tartareous Acid dissolves the Oxide of Tin. When Tartar is used, therefore, in any considerable quantity, the mordant is not a Nitro-muriate, but a Tartrite of Tin.

Iron, like Tin, is capable of two degrees of oxidation; but the green Oxide absorbs Oxygen so readily from the atmosphere, that it is very soon converted into the red Oxide. It is only this last Oxide which is really used as a mordant in dyeing. The green Oxide is, indeed, sometimes applied to cloth; but very soon absorbs Oxygen, and is converted into the red Oxide. This Oxide has a very strong affinity for all kinds of cloth. The permanency of the iron-spots on linen and cotton is a sufficient proof of this. As a mordant, it is used in two states; in that of Sulphate of Iron (copperas), and Acetite of Iron. The first is commonly used for wool. The salt is dissolved in water, and the cloth dipped in it. It may be used also for cotton, but in most cases Acetite of Iron is preferred. It is prepared by dissolving Iron, or its Oxide, in vinegar, sour beer, or Pyroligneous Acid, and the longer it is kept, the more it is preferred. The reason is, that this mordant succeeds best, when the Iron is in the state of red Oxide. It would be better, then, to oxidate the Iron, or convert it into rust, before using it; which might be easily done, by keeping it for some time in a moist place, and sprinkling it occasionally with water.

Tan has a very strong affinity for cloth, and for several colouring matters; it is therefore very frequently employed as a mordant. An infusion of nut-galls, or of sumach, or of any other substance containing Tan, is made in water, and the cloth is dipped in this infusion, and allowed to remain till it has absorbed a sufficient quantity of Tan. Silk is capable of absorbing a very great proportion of Tan, and by that means acquires a great increase of weight. Manufacturers sometimes employ this method of increasing the weight of silk.

Tan is often employed also, along with other mordants, in order to produce a compound mordant. Oil is also used for the same purpose, in the dyeing of cotton and linen. The mordants with which Tan is most frequently combined, are Alumine, and Oxide of Iron.

Besides these mordants, there are several other substances frequently used as auxiliaries, either to facilitate the combination of the mordant with the cloth, or to alter the shade of colour; the chief of these are, Tartar, Acetate of Lead, Common Salt, Sal-Ammoniac, Sulphate, or Acetite of Copper, &c.

Mordants not only render the dye permanent, but have also considerable influence on the colour produced. The same colouring matter produces very different dyes, according as the mordant is changed. Suppose, for instance, that the colouring matter is Cochineal; if we use the aluminous mordant, the cloth will acquire a crimson colour; but the Oxide of Iron produces with it, a black.

In dyeing, then, it is not only necessary to procure a mordant which has a sufficiently strong affinity for the colouring matter and the cloth, and a colouring matter which possesses the wished-for colour in perfection; but we must procure a mordant and a colouring matter of such a nature, that when combined together, they shall possess the wished-for colour, in perfection. It is evident too, that a great variety of colours may be produced with a single dye-stuff, provided we can change the mordant sufficiently.

The colouring matter with which the cloth is dyed, does not cover every portion of its surface; its particles attach themselves to the cloth at certain distances from each other; for cloth may be dyed different shades of the same colour, lighter or darker, merely by varying the quantity of colouring matter. With a small quantity, the shade is light; and it becomes deeper, as the quantity increases. Now this would be impossible, if the dye-stuff covered the whole of the cloth.

That the particles of colouring matter, even when the shade is deep, are at some distance, is evident from this well-known fact, that cloth may be dyed of two colours at the same time. All those colours to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a green colour, by being first dyed blue, and then yellow.

The colours denominated, by dyers, simple, because they are the foundation of all their other processes, are four; namely, blue, yellow, red, and black. To these they usually add a fifth, under the name of root, or brown colour.

Blue Dyes.

The only colouring matters employed in dyeing blue, are woad and indigo.

Woad is a plant cultivated in this kingdom, and even grows wild in some parts of England. Indigo is a blue powder, extracted from a oxide of iron, for instance, and different metallic sulphurets. If, therefore, indigo, lime, and green sulphate of iron, are mixed together in water, the indigo gradually loses its blue colour, becomes green, and is dissolved: while the green oxide of iron is converted into the *red* oxide. The manner in which these changes take place is obvious; part of the lime decomposes the sulphate of iron; the green oxide, the instant that it is set at liberty, attracts oxygen from the indigo, decomposes it, and reduces it to the state of green pollen. This green pollen is immediately dissolved by the action of the rest of the lime.

The second method is, to mix the indigo, in water, with certain vegetable substances which readily undergo fermentation; the indigo is deprived of its oxygen, and dissolved by means of quick-lime or alkali, which is added to the solution. The first of these methods is usually followed in dyeing cotton and linen; the second, in dyeing wool and silk.

In the dyeing of wool, woad and bran are commonly employed as vegetable ferments, and lime as the solvent of the green base of the indigo. Woad itself contains a colouring matter precisely similar to indigo; and by following the common process, indigo may be extracted from it. In the usual state of woad, when purchased by the dyer, the indigo, which it contains, is probably not far from the state of green pollen. Its quantity in woad is but small, and it is mixed with a great proportion of other vegetable matter.

When the cloth is first taken out of the vat, it is of a green colour; but it soon becomes blue, by attracting oxygen from the air. It ought to be carefully washed, to carry off the uncombined particles. This solution of indigo is liable to two inconveniences: first, it is apt sometimes to run too fast into the putrid fermentation; this may be known by the putrid vapours which it exhales, and by the disappearing of the green colour. In this state it would soon destroy the indigo altogether. The inconvenience is remedied by adding more lime, which has the property of moderating the putrescent tendency. Secondly, sometimes the fermentation goes on too languidly. This defect is remedied by adding more bran, or woad, in order to diminish the proportion of quick-lime.

DCCXC.

TO DYE SILK OF A BLUE COLOUR.

Silk is dyed light-blue by a ferment of six parts of Bran, six of Indigo, six of Potass, and one of Madder. To dye it of a dark blue, it must previously receive what is called a *ground-colour;* a red dye-stuff, called archil, is used for this purpose.

DCCXCI.

TO DYE COTTON AND LINEN OF A BLUE COLOUR.

Cotton and linen are dyed blue by a solution of one part of Indigo, one part of green Sulphate of Iron, and two parts of quick-lime.

YELLOW DYES.

The principal colouring matters for dyeing yellow, are weld, fustic, and quercitron bark.

Weld is a plant which grows commonly in this country; Fustic is the wood of a large tree which grows in the West Indies, and Quercitron is a tree growing in North America, the bark of which côntains colouring matter.

Yellow colouring matters have too weak an affinity for cloth, to produce permanent colours without the use of mordants. Cloth, therefore, before it is dyed yellow, is always prepared by combining some mordant or other with it. The mordant most commonly employed for this purpose, is alumine. Oxide of tin is sometimes used when very fine yellows are wanting. Tan is often employed as subsidiary to alumine, and in order to fix it more copiously on cotton and linen. Tartar is also used as an auxiliary, to brighten the colour; and muriate of soda, sulphate of lime, and even sulphate of iron, in order to render the shade deeper.

The yellow dye by means of fustic is more permanent, but not so beautiful as that given by weld, or quercitron. As it is permanent, and not much injured by acids, it is often used in dyeing compound colours, where a yellow is required. The mordant is alumine. When the mordant is oxide of iron, fustic dyes a good permanent drab colour.

Weld, and quercitron bark yield nearly the same kind of colour; but as the bark yields colouring matter in much greater abundance, it is much more convenient, and upon the whole, cheaper than weld. It is probable, therefore, that it will gradually supersede the ùse of that plant. The method of using each of these dye-stuffs is nearly the same.

DCCXCII.

TO DYE WOOLLENS OF A YELLOW COLOUR.

Wool may be dyed yellow by the following process: let it be boiled for an hour, or more, with about $\frac{1}{6}$th of its weight of alum, dissolved in a sufficient quantity of water. It is then to be plunged, without being rinsed, into a bath of warm water, containing as much Quercitron bark, as equals the weight of the alum employed as a mordant. The cloth is to be turned through the boiling liquid, till it has acquired the intended colour. Then, a quantity of clean powdered chalk, equal to the hundredth part of the weight of the cloth, is to be stirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given, fully as permanent as weld yellow.

Observations. For very bright orange, or golden yellow, it is necessary to have recourse to the oxide of tin as a mordant.

For producing bright golden yellows, some alum must be added along with the tin.

In order to give the yellow that delicate green shade so much admired for certain purposes, tartar must be added in different proportions, according to the shade.

By adding a small portion of cochineal, the colour may be raised to a fine orange, or even to an aurora.

DCCXCIII.

To Dye Silks of a Yellow Colour.

Silk may be dyed of different shades of yellow, either by Weld or Quercitron bark, but the last is the cheapest of the two. The proportion should be from one, to two parts, of bark to twelve parts of silk, according to the shade. The bark, tied up in a bag, should be put into the dyeing vessel, whilst the water which it contains is cold; and when it has acquired the heat of about 100°, the silk, having been previously alumed, should be dipped in, and continued, till it assumes the wished-for colour. When the shade is required to be deep, a little chalk, or pearl-ash, should be added towards the end of the operation.

DCCXCIV.

To Dye Linnes and Cottons of a Yellow Colour.

The best method of dyeing cotton and linen yellow, is as follows:—

The mordant should be Acetate of Alumine, prepared by dissolving one part of Acetate of Lead, and three parts of alum, in a sufficient quantity of water. This solution should be heated to the temperature of 100°: the cloth should be soaked in it for two hours, then wrung out and dried. The soaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with Lime water, and afterwards dried. The soaking in the Acetate of Alumine may be again repeated; and if the shade of yellow is required to be very bright and durable, the alternate wetting with Lime-water and soaking in the mordant may be repeated three or four times. By this contrivance, a sufficient quantity of Alumine is combined with the cloth, and the combination is rendered more permanent by the addition of Lime. The dyeing-bath is prepared by putting 12, or 18, parts of Quercitron bark (according to the depth of the shade required), tied up in a bag, into a sufficient quantity of cold water. Into this bath the cloth is to be put, and turned round in it for an hour, while its temperature is gradually raised to about 120°. It is then to be brought to a boiling heat, and the cloth allowed to remain in it, after that, only for a few minutes. If it is kept long at a boiling heat, the yellow acquires a shade of brown.

DCCXCV

MODE OF FIXING A VERY FINE MINERAL YELLOW *Upon Wool, Silk, Cotton, Hemp, &c. by*

M. HENRI BRACONNOT.

All the colours employed in the art of dyeing, (with the exception of Prussian blue, which will not fix upon every kind of stuff, and Prussiate of Copper, and Oxide of Iron, which give solid, rather than brilliant tints) are derived from organic matters, because they are more easily applied than mineral colours, but they are also more or less alterable by time. The yellows are peculiarly liable to fade; and if the intervention of mordants will render the dye of Weld more permanent, it is at the expence of its lustre.

The mineral substance which I have succeeded in fixing upon stuffs, and which I now recommend to dyers as the most brilliant and permanent yellow that can be imagined, is the *sulphuret of arsenic*, or *realgar*, which also is used to furnish a very lively permanent yellow to the painter, when care is taken to keep it free from other Metallic Oxides which tarnish its lustre.

The preparation of realgar which I employ, is its solution in ammonia; but it is necessary to bring the sulphuret to a certain state of division before it will easily dissolve in this alkali. The process is the following: Mix one part of Sulphur, two parts of white Oxide of Arsenic, and five parts of Pearlash; and melt the whole in a crucible, at a heat a little short of redness. The result is a yellow mass, which is to be dissolved in hot water; and the liquor filtrated, to separate it from a sediment formed chiefly of Metallic Arsenic, in shining plates, and in a small part, of a chocolate-coloured matter, which appears to be a Sub-sulphuret of Arsenic. Dilute the fibrated liquor, then add weak Sulphuric Acid, which produces a flocculent precipitate, of a most brilliant yellow colour. This precipitate, washed upon a cloth filter, dissolves with the utmost ease in liquid Ammonia, giving a yellow solution, which colour is to be removed by an excess of the same alkali. This solution is the dyeing liquid in question; into which, more or less diluted, according to the depth of tint required, the wool, silk, cotton, or linen, is to be dipped. All Metallic utensils must be carefully avoided. When the stuffs come out of this bath they are colourless, but they insensibly take on a yellow hue as the Ammonia evaporates. They are to be exposed as equally as possible to a current of open air; and when the colour is well come out, and no longer heightens, they are to be washed and dried.

Wool should be fulled in the ammoniacal solution, and should remain in it till it is thoroughly soaked; then, very slightly and uniformly pressed, or else merely set to drain of itself. Silk, cotton, hemp, and flax, are only to be dipped in the dyeing liquid, which they easily take. They must then be well pressed.

Observations. The sulphuret of arsenic will give every imaginable tint to stuffs from the deep golden yellow to the lightest straw-colour, which has the invariable advantage of never fading, of lasting even longer than the stuffs themselves, and of resisting all re-agents except alkalies. Hence it is peculiarly fitted for costly tapestry, velvets, and other articles of furniture which are not in danger of being washed with alkalies or soap, and to which the durability of colour is a most important object. It may also be used with advantage in paper-staining.

It appears to me that the low price and easy applications of this colouring liquid will render it an important acquisition to the art of dyeing.

When the sulphuret of arsenic is dissolved in ammonia, a small portion of the arsenic becomes oxidated; for if an excess of lime-water is poured in, there is a white precipitate of arseniate of lime. This oxidation appears also to take place spontaneously, when a pretty strong solution of the ammoniacal liquid is exposed for a time to the air, and is shewn by the formation of small crystals of arseniate of ammonia: or if an acid is added, sulphuret of arsenic falls down, mixed with a pale yellow sulphuretted oxide of arsenic. On this account it is better to make no more of the solution at a time than is wanted for use.

With regard to the danger to be apprehended from the poisonous quality of this metal, though the native realgar from it mixture with oxide of arsenic, is not free from hazard, the artificial sulphuret, when obtained in the way above-mentioned, appears to me to be quite innocent; at least I have given pretty large doses of it to dogs and cats, which these animals have borne without inconvenience.

RED DYES.

The colouring matters employed for dyeing red, are kermes, cochineal, archil, madder, carthamus, and Brazil-wood.

Kermes is a species of insect, affording a red colour by solution in water; but it is not so beautiful as cochineal, which is likewise an insect, brought from America. The decoction of cochineal is of a very beautiful crimson-colour. Alum brightens the colour of the decoction, and occasions a crimson precipitate. Muriate of tin gives a copious fine red precipitate.—Archil is a paste formed of a species of lichen pounded, and kept moist for some time with stale urine.—Madder is the root of a well-known plant, rubia tinctorum.—Carthamus is the flower of a plant cultivated in Spain and the Levant. It contains two colouring matters: a yellow, which is soluble in water; and a red, insoluble in water, but soluble in alkaline carbonates. The red colouring matter of carthamus, extracted by carbonate of soda, and precipitated by lemon-juice, constitutes the rouge employed by ladies as a paint. It is afterwards ground with a certain quantity of talc. The fineness of the talc, and the proportion of it mixed with the carthamus, occasion the difference between the cheaper and dearer kinds of rouge.—Brazil-wood is the wood of a tree growing in America and the West Indies. Its decoction is of a fine red colour.

None of the red colouring matters has so strong an affinity for cloth as to produce a permanent red, without the assistance of mordants. The mordants employed are alumine, and oxide of tin; oil, and tan, in certain processes, are also used; and tartar, and muriate of Soda, are frequently called in as auxiliaries.

DCCXCVI.

TO DYE WOOLLENS OF RED, CRIMSON, AND SCARLET *Colours.*

Coarse Woollen stuffs are dyed red with madder or archil: but fine cloth is almost exclusively dyed with Cochineal, though the colour which it receives from Kermes is much more durable. Brazil-wood is scarcely used, except as an auxiliary, because the colour which it imparts to Wool is not permanent.

Wool is dyed crimson, by first impregnating it with Alumine, by means of an alum bath, and then boiling it in a decoction of Cochineal, till it has acquired the wished-for colour. The crimson will be finer, if the tin mordant is substituted for alum; indeed, it is usual with dyers to add a little Nitro-Muriate of Tin, when they want fine crimsons. The addition of Archil and Potass to the Cochineal, both renders the crimson darker, and gives it more bloom; but the bloom very soon vanishes. For paler crimsons, one-half of the Cochineal is withdrawn, and Madder substituted in its place.

Wool may be dyed scarlet, the most splendid of all colours, by first boiling it in a solution of Murio-Sulphate of Tin, then dyeing it pale yellow with Quercitron bark, and afterwards crimson with Cochineal; for, scarlet is a compound colour consisting of crimson mixed with a little yellow.

Observations. It is well known that cloth dyed in the piece is never saturated throughout with the colouring matter. Indeed such cloths may be distinguished from those dyed in the wool, by examining their edges when cut; for their interior is always of a fainter tint than the surfaces—sometimes almost white. If, to avoid this, the cloth be made of wool dyed before spun, it is more expensive, but becomes more agreeable to wear, never showing white edges. Some colours can only be given to cloth after it is manufactured; for example, cochineal scarlet, the beauty of which would be impaired by carding, spinning, and fulling. Scarlet is therefore always dyed in the piece, and liable to exhibit white edges. The discovery of the Count de la Boulaye-Marsillac, director and professor in the school of the Gobelins, entirely removes this defect. His theory is, that the water with which the cloth is soaked before immersion in the dye-vat, occupying already the interstices of the cloth, prohibits the entrance of the colouring liquid; so that the cloth, though strongly wrung to displace the water, is able only to receive the colouring matter to a certain depth. His aim then was to have the cloth so moistened as to be fit for the process, and yet to have the water so completely removed from the interior of the cloth, as to permit the dye to enter; and this he effects by making the moistened cloth pass through between rollers placed within and at the bottom of the dye-vat; so that, the web passing from one windlass through the dye-vat, and being strongly compressed by the rollers in its passage to another windlass, all the remaining water is driven out into the colouring liquid (and diluting it to that extent), and is replaced by the colouring liquid, so as to receive colour into its very centre. The winding is continued backwards and forwards from one windlass to the other, and through the rolling-press, till the dye is of sufficient intensity. Cloths thus dyed, are of so intense a colour as to appear less bright than scarlets are by the common process; but this deeper reflection of red rays may be obviated by adding, to the bath, some turmeric or fustic.

DCCXCVII.

TO DYE SILKS OF RED, CRIMSON, AND OTHER COLOURS.

Silk is usually dyed red with Cochineal, or Carthamus, and sometimes with Brazil-wood. Kermes does not answer for silk; Madder is scarcely ever used for that purpose, because it does not yield a colour bright enough. Archil is employed to give silk a bloom; but it is scarcely ever used by itself, unless when the colour, wanted, is lilac.

Silk may be dyed crimson, by steeping it in a solution of alum, and then dyeing it in the usual way in a Cochineal bath.

The colours known by the names of *poppy*, *cherry*, *rose*, and *flesh-colour*, are given to silk my means of Carthamus. The process consists merely in keeping the silk as long as it extracts any colour, in an alkaline solution of Carthamus, into which as much lemon-juice, as gives it a fine cherry-red colour, has been poured.

Silk cannot be dyed a full scarlet: but a colour approaching to scarlet may be given to it, by first impregnating the stuff with Murio-Sulphate of Tin, and afterwards dyeing it in a bath, composed of four parts of Cochineal, and four parts of Quercitron bark. To give the colour more body, both the mordant and the dye may be repeated. A colour, approaching to scarlet, may also be given to silk, by first dyeing it in crimson, then dyeing it with carthamus; and lastly, yellow, without heat.

DCCXCVIII.

To Dye Linens and Cottons, of Red, Scarlet, *And other Colours.*

Cotton and linen are dyed red with Madder. The process was borrowed from the East; hence the colour is often called Adrianople, or Turkey-red. The cloth is first impregnated with oil, then with galls, and lastly with alum. It is then boiled for an hour in a decoction of madder, which is commonly mixed with a quantity of blood. After the cloth is dyed, it is plunged into a soda ley, in order to brighten the colour. The red given by this process, is very permanent; and when properly conducted, it is exceedingly beautiful. The whole difficulty consists in the application of the mordant, which is by far the most complicated employed in the whole art of dyeing.

Cotton may be dyed scarlet, by means of Murio-sulphate of Tin, Cochineal, and Quercitron bark, used as for silk, but the colour is too fading to be of any value.

Black Dyes.

The substances employed to give a black colour to cloth, are, red oxide of iron, and tan. These two substances have a strong affinity for each other, and when combined, assume a deep black colour, not liable to be destroyed by the action of air or light.

Logwood is usually employed as an auxiliary, because it communicates lustre, and adds considerably to the fulness of the black. It is the wood of a tree which is a native of several of the West-India islands, and of that part of Mexico which surrounds the Bay of Honduras. It yields its colouring matter to water. The decoction is at first a fine red, bordering on violet; but if left to itself, it gradually assumes a black colour. Acids give it a deep red colour; alkalis a deep violet, inclining to brown; sulphate of iron renders it as black as ink, and occasions a precipitate of the same colour.

Cloth, before it receives a black colour, *is usually dyed blue*: this renders the colour much fuller and finer than it would otherwise be. If the cloth is coarse, the blue dye may be too expensive; in that case, a brown colour is given, by means of walnut-peels.

DCCXCIX

TO DYE WOOLLENS OF A BLACK COLOUR.

Wool is dyed black by the following process. It is boiled for two hours in a decoction of nut-galls, and afterwards kept, for two hours more, in a bath composed of Logwood and Sulphate of Iron; kept during the whole time at a scalding heat, but not boiling. During the operation, it must be frequently exposed to the air: because the green Oxide of Iron, of which the Sulphate is composed, must be converted into red Oxide by absorbing Oxygen, before the cloth can acquire a proper colour. The common proportions, are five parts of galls, five of Sulphate of Iron, and thirty of Logwood, for every hundred of cloth. A little Acetite of Copper is commonly added to the Sulphate of Iron, because it is thought to improve the colour.

DCCC.

TO DYE SILKS OF A BLACK COLOUR.

Silk is dyed nearly in the same manner. It is capable of combining with a great deal of Tan; the quantity given is varied at the pleasure of the artist, by allowing the silk to remain a longer, or shorter time, in the decoction.

DCCCI.

TO DYE COTTONS AND LINENS OF A BLACK COLOUR.

It is by no means easy to give a full black to linen and cotton. The cloth, *previously dyed blue*, is steeped for 24 hours in a decoction of nut-galls. A bath is prepared containing Acetite of Iron, formed by saturating Acetous Acid with brown Oxide of Iron: into this bath the cloth is put, in small quantities at a time, wrought with the hand for a quarter of an hour; then wrung out, and aired again; wrought in a fresh quantity of the bath, and afterwards aired. These alternate processes are repeated till the colour, wanted, is given: a decoction of alder-bark is usually mixed with the liquor containing the nut-galls.

DCCCII.

TO DYE WOOL, &C. OF A BROWN COLOUR.

Brown, or fawn colour, though in fact a compound, is usually ranked among the simple colours, because it is applied to cloth by a single process. Various substances are used for brown dyes.

Walnut-peels, or the green covering of the walnut, when first separated are white internally, but soon assume a brown or even a black colour, on exposure to the air. They readily yield their colouring matter to water. They are usually kept in large casks, covered with water, for above a year before they are used. To dye wool brown with them, nothing more is necessary, than to steep the cloth in a decoction of them till it has acquired the wished-for colour. The depth of the shade is proportional to the strength of the decoction.

Observations. The root of the walnut-tree contains the same colouring matter, but in smaller quantity. The bark of the birch also, and many other trees, may be used for the same purpose. It is very probable that the brown colouring matter is, in these vegetable substances, combined with tan. This is certainly the case in sumach, which is often employed to produce a brown. This combination explains the reason, why no mordant is necessary; the tan has a strong affinity for cloth, and the colouring matter for the tan. The dye-stuff, and the mordant, are already, in fact, combined together.

COMPOUND COLOURS.

Compound colours are produced by mixing together two simple ones; or, which is the same thing, by dyeing cloth, first, of the simple colour, and then by another. These colours vary to infinity, according to the proportions of the ingredients employed.

DCCCIII.

TO DYE DIFFERENT SHADES OF GREEN.

Green is distinguished by dyers into a variety of shades, according to the depth, or the prevalence of either of the component parts. Thus we have sea-green, grass-green, pea-green, &c.

Wool, silk, and linen, are usually dyed green, by giving them first a blue colour, and afterwards dyeing them yellow; when the *yellow* is first given, several inconveniences follow: the yellow partly separates again in the blue vat, and communicates a green colour to it; thus rendering it useless for every other purpose, except dyeing green. Any of the usual processes for dyeing blue and yellow may be followed, taking care to proportion the depth of the shades to that of the green required. When Sulphate of Indigo is employed, it is usual to mix all the ingredients together, and to dye the cloth at once; this produces what is known by the name of Saxon, or English green.

DCCCIV.

To Dye Violet, Purple, and Lilac.

Wool is generally first dyed blue, and afterwards scarlet, in the usual manner. By means of Cochineal mixed with Sulphate of Indigo, the process may be performed at once. Silk is first dyed crimson, by means of Cochineal, and then dipped into the Indigo vat. Cotton and linen are first dyed blue, then galled, and soaked in a decoction of Logwood; but a more permanent colour is given by means of Oxide of Iron.

DCCCV.

To Dye Olive, Orange, and Cinnamon Colours.

When blue is combined with red and yellow on cloth, the resulting colour is olive. Wool may be dyed orange, by first dyeing it scarlet, and then yellow. When it is dyed first with Madder, the result is a cinnamon-colour.

Silk is dyed orange by means of Carthamus; a cinnamon colour by Logwood, Brazil-wood, and Fustic mixed together.

Cotton and linen receive a cinnamon colour by means of Weld and Madder; and an olive colour by being passed through a blue, yellow, and then a Madder-bath.

DCCCVI.

To Dye of Grey, Drab, and Dark-Brown Colours.

If cloth is previously combined with brown Oxide of Iron, and afterwards dyed yellow with Quercitron bark, the result will be a drab of different shades, according to the proportion of mordant employed. When the proportion is small, the colour inclines to olive, or yellow; on the contrary, the drab may be deepened, or *saddened*, as the dyers term it, by mixing a little Sumach with the bark.

Callico-printing.

This art consists in dyeing cloth with certain colours and figures upon a ground of a different hue; the colours, when they will not take hold of the cloth readily, being fixed to them by means of mordants, or substances that have a chemical affinity, or attraction, both for the materials that form the colour, and for the cloth to which the colour is to be applied.

The mordant principally used, is a preparation of alum, made by dissolving 3 lbs. of alum and 1 lb. of acetate of lead in 8 lbs. of warm water. An exchange of the principles of these salts takes place: the sulphuric acid of the alum combines with the oxide of lead, and the compound thus formed being insoluble, is precipitated, the acetic acid remains united with the alumine in solution. There are added at the same time two ounces of potash, and two ounces of chalk, to neutralize the excess of acid that might act on the colouring matter.

The superiority of acetate of alumine, as a mordant, to the sulphate of alumine, arises principally from two circumstances;—1st, from the affinity, between its principles, being weaker, in consequence of which, the alumine more easily separates from the acid, and unites with the cloth and the colouring matter; and, 2dly, from the acetic acid disengaged in the process not acting with the same force on the colouring matter, as the sulphuric acid would do. The acetate being also very soluble, and having little tendency to crystallize, can be more equally mixed and applied. The discovery of this mordant, so essential in the art of callico-printing, was accidental. Acetite of iron, also, is a mordant in frequent use in the printing of callicoes.

The recipes of the calico-printers were at one time very complicated: different articles being, from time to time, omitted or changed, until at length the simple mixture of alum and acetate of lead, was found to answer as a mordant, equally with compositions more complicated.

The mordants chiefly employed in callico-printing, are acetite of alumine, and acetite of iron. The mordants are applied to the cloth, either with a pencil, or by means of blocks, on which the pattern, according to which the cotton is to be printed, is cut. As they are applied only to particular parts of the cloth, care must be taken that none of them spread to the part of the cloth which is to be left white, and that they do not interfere with one another when several are applied. If these precautions are not attended to, all the elegance and beauty of the print must be destroyed. It is necessary, therefore, that the mordants should be of such a degree of consistence, that they will not spread beyond those parts of the cloth on which they are applied. This is done by thickening them with flour or starch, when they are to be applied by the block; and with gum-arabic, when they are to be put on by the pencil. The thickening should never be greater than is sufficient to prevent the spreading of the mordants; when carried too far, the cotton is apt not to be sufficiently saturated with the mordants; of course the dye takes but imperfectly.

In order that the parts of the cloth impregnated with mordants may be distinguished by their colour, it is usual to tinge the mordants with some colouring matter or other. The printers commonly use the decoction of Brazil-wood for this purpose; but Dr. Bancroft has objected to this method, because he thinks that the Brazil-wood colouring matter impedes the subsequent process of dyeing. It is certain that the colouring matter of the Brazil-wood is displaced, during that operation, by the superior affinity of the dye-stuff of the mordants. Was it not for this superior affinity, the colour would not take at all. Dr. Bancroft advises to colour the mordant with some of the dye-stuff afterwards to be applied; and he cautions the using of more for that purpose, than is sufficient to make the mordant distinguishable when applied to the cloth. The reason of this precaution is obvious. If too much dye is mixed with the mordant, a great proportion of the mordant will be combined with the colouring matter, which must weaken its affinity for the cloth, and of course prevent it from combining with it in sufficient quantity to ensure a permanent dye.

Sometimes, the two mordants are mixed together in different proportions; and sometimes one or both is mixed with an infusion of sumach, or of nut-galls. By these contrivances, a great variety of colours are produced by the same dye-stuff.

After the mordants have been applied, the cloth must be completely dried. It is proper for this purpose to employ heat, which will contribute considerably towards the separation of the acetous acid from its base, and towards its evaporation; by which means the mordant will combine in a greater proportion, and more intimately with the cloth.

When the cloth is sufficiently dried, it is to be washed with warm water and cow-dung; till all the flour, or gum, employed to thicken the mordants; and all those parts of the mordants which are uncombined with the cloth, are removed. After this, the cloth is to be thoroughly rinsed in clean water.

Almost the only dye-stuffs employed by callico-printers are indigo, madder, and quercitron bark, or weld. This last substance, however, is but little used, except for delicate greenish yellows. The quercitron bark has almost superseded it, because it gives colours equally good; and is much cheaper and more convenient, not requiring so great a heat to fix it. Indigo, not requiring any mordant, is commonly applied at once, either by a block or by a pencil. It is prepared by boiling together indigo and potash made caustic by quick-lime, and orpiment; the solution is afterwards thickened with gum. It must be carefully secluded from the air, otherwise the indigo would soon be regenerated, which would render the solution useless. Dr. Bancroft has proposed to substitute coarse brown sugar for orpiment: it is equally efficacious in decomposing the indigo, and rendering it soluble; while it likewise serves all the purposes of gum.

Some callicoes are only printed of one colour, others have two, and others three or more, even to the number of eight, ten, or twelve. The smaller the number of colours, the fewer, in general, are the processes.

DCCCVII.

NANKEEN YELLOW.

One of the most common colours on cotton prints, is a kind of nankeen yellow, of various shades down to a deep yellowish brown, or drab. It is usually in stripes or spots. To produce it, the printers besmear a block, cut out into the figure of the print, with Acetite of Iron, thickened with gum or flour; and apply it to the cotton, which, after being dried and cleansed in the usual manner, is plunged into a potash ley. The quantity of Acetite of Iron is always proportioned to the depth of the shade.

DCCCVIII.

YELLOW.

For yellow, the block is besmeared with Acetite of Alumine. The cloth, after receiving this mordant, is dyed with Quercitron bark, and is then bleached.

DCCCIX.

RED.

Red is communicated by the same process, only Madder is substituted for the bark.

DCCCX.

BLUE.

The fine light blues which appear so frequently on printed cottons, are produced by applying to the cloth a block besmeared with a composition, consisting partly of wax, which covers all those parts of the cloth which are to remain white. The cloth is then died in a cold Indigo vat; and after it is dry, the wax composition is removed by hot water.

DCCCXI.

LILAC AND BROWN.

Lilac, flea brown, and blackish brown, are given by means of Acetite of Iron; the quantity of which is always proportioned to the depth of the shade. For very deep colours, a little sumach is added. The cotton is afterwards dyed in the usual manner with Madder, and then bleached.

DCCCXII.

A LASTING GREEN COLOUR, FOR PRINTING COTTONS, *Cambrics, Linens, &c.*

To twelve quarts of Muriatic Acid, add, by degrees, one quart of Nitrous Acid; saturate the whole with grain tin, and boil it in a proper vessel till two-thirds are evaporated.

To prepare the indigo for mixing with the solution, take nine pounds of Indigo, half a pound of orange Orpiment, and grind it in about four quarts of water. Then take three pounds of gum senegal; dissolve it in four quarts of water, mix it well with the Indigo; and grind the whole in the usual way.

Observations. The manner of mixing the solution of tin with the prepared indigo to make it fit for printing, is thus:—Take two gallons of the indigo prepared as above, then stir into it, by degrees, one gallon of the solution of tin, neutralized by as much caustic alkali as can be added without precipitating the tin from the acids. It will now be fit for use, and may be applied in the usual way. For a lighter shade of green, less indigo will be necessary. After being printed, the goods are to be dipped in the way of dipping China blues; they must not, however, be allowed to drain, but moved from one vat to another as quickly as possible. They are to be cleansed in the usual way, in a sour vat of about 150 gallons of water to one gallon of sulphuric acid; they are then to be well washed in decoctions of weld, and other yellow colouring drugs, and are to be branned or bleached till they become white in those parts which are required to be colourless.

DCCCXIII.

DOVE COLOUR AND DRAB.

Dove colour and drab are given by Acetite of Iron and quercitron bark; the cloth is afterwards prepared in the usual manner.

Observation. When different colours are to appear in the same print, a greater number of operations are necessary. Two or more blocks are employed; upon each of which, that part of the print only is cut, which is to be of some particular colour. These are besmeared with different mordants, and applied to the cloth, which is afterwards dyed as usual.

Let us suppose, for instance. that these blocks are applied to cotton, one with acetite of alumine, another with acetite of iron, a third with a mixture of those two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants would have the following colours.

Acetite of alumine,	Yellow.
——— iron,	Olive, drab, dove.
The mixture,	Olive green, olive.

If the part of the yellow is covered over with the indigo liquor, applied with a pencil, it will be converted into *green*. By the same liquid, blue may be given to such parts of the print as require it.

If the cotton is dyed with madder, instead of quercitron bark, the print will exhibit the following colours.

Acetite of alumine,	- Red.
——— iron,	Brown, black.
The mixture,	Purple.

When a greater number of colours are to appear; for instance, when those communicated by bark, and those by madder, are wanted at the same time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath, and bleached; then the rest of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark, and bleached. The second dyeing does not much affect the madder colours; because the mordants, which render them permanent, are already saturated. The yellow tinge is easily removed by the subsequent bleaching. Sometimes a new mordant is also applied to some of the madder colours, in consequence of which, they receive a new permanent colour from the bark. After the last bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours which may be given to cotton by these complicated processes.

I. *Madder Dye.*

	Colours.
Acetite of alumine,	Red.
——— iron,	Brown, black.
——— diluted,	Lilac.
Both, mixed,	Purple.

II. *Bark Dye.*

Acetite of alumine,	Yellow.
——— iron,	Dove, drab.
Lilac and acetite of alumine,	Olive.
Red and acetite of alumine,	Orange.

III. *Indigo Dye.*

Indigo,	Blue.
Indigo and yellow,	Green.

Thus, no less than twelve colours may be made to appear together in the same print, by these different processes.

If it was possible to procure colours sufficiently permanent, by applying them, at once, to the cloth by the block or the pencil, as is the case with the mordants; the art of calico-printing would be brought to the greatest possible simplicity: but at present, this can only be done in one case, that of indigo; every other colour requires dyeing. Compositions, indeed, may be made, by previously combining the dye-stuff and the mordants. Thus *yellow* may be applied at once, by employing a mixture of the infusion of quercitron bark and acetite of alumine; *red*, by mixing the same mordant with the decoction of alumine, and so on. The colours applied in this way are, unfortunately, far inferior in permanency to those produced when the mordant is previously combined with the cloth, and the dye stuff afterwards applied separately. In this way are applied almost all the fugitive colours of callicoes, which washing, or even exposure to the air, destroys. As the application of colours, in this way, cannot always be avoided by callico-printers, every method of rendering them more permanent, is an object of importance.

Colouring of Paper Hangings.

There are three methods of effecting this. The first by printing the colours; the second by using the stencil; and the third by laying them on with a pencil, as in other kinds of painting.

DCCCXIV.

Printing the Colours.

When the colours are laid on by printing, the impression is made by wooden prints, which are cut in such a manner, that the figure to be expressed is made to project from the surface, by cutting away all the other part; and this, being charged with the colours properly tempered (by letting it gently down on the block on which the colour is previously spread,) conveys it to the ground of the paper, on which it is made to fall forcibly by means of its weight, and by the effort of the arm of the person who uses the print. There must be as many separate prints as there are colours to be printed. But where there are more than one, great care must be taken, after the first, to let the print fall exactly on the same part of the paper as that which went before; otherwise, the figure of the design would be brought into irregularity and confusion.

DCCCXV.

STENCILLING.

On common paper of low price, it is usual to print only the outlines, and lay on the rest of the colours by Stencilling, which saves the expence of cutting more prints, and can be practised by common workmen, as it does not require the great care and dexterity necessary to the use of the several prints. The manner of stencilling the colours is this: The figure, which all the parts of any particular colour make in the design to be painted, is to be cut out in a piece of tinned iron, thin leather, or oil-cloth; these pieces are called stencils; and being laid flat on the sheets of paper to be printed, spread on a table or floor, are to be rubbed over with the colour, properly tempered, by means of a large brush. The colour passing over the whole, is consequently spread on those parts of the paper where the tin, cloth, or leather is cut away, and give the same effect as if laid on by a print. This is, nevertheless, only practicable in parts where there are only detached masses or spots of colours; for where there are small continued lines, or parts that run one into another, it is difficult to preserve the connection or continuity of the parts of the cloth, or to keep the smaller corners close down to the paper: therefore, in such cases, prints are preferable.

Observations. Stencilling, is, indeed, a cheaper method for coarse work than printing; but without such extraordinary attention and trouble as render it equally difficult with printing, it is far less beautiful and exact in the effect. For, the outline of the spots of colour wants that sharpness and regularity that are given by prints; besides the frequent extralineations, or deviations from the just figure, which happen by the misplacing of the stencils, or shifting the place of them, during the operation.

nish on the paper, and having afterwards printed the design of the flock in varnish, in the same manner as for the true; instead of the flock, some pigment, or dry colour, of the same hue with the flock required by the design, (but somewhat of a darker shade,) being well powdered, is strewed on the printed varnish, and produces nearly the same appearance.

Observations. A Mr. Middleton communicated some improvements in the printing of paper-hangings, to the Society of Arts. They are intended to facilitate the conveyance of the paper over the printing-table, and to give a greater pressure than usual to the block, when printing dark grounds.

To facilitate the conveyance of the paper, two cords 36 feet long, are stretched from the printer's table, to the other end of the room, through rings, where they are kept tight by a weight appended to their extremities. The paper to be printed is rolled up on a wooden roller at one side of the table, and its end is brought across the table, and fastened between two flat ledges that are connected at one end by a hinge, and at the other by a sliding ring; these ledges slide along the two cords on pullies placed at each end of them, and serve to draw forward the paper as it is printed: from the middle of these ledges, a cord proceeds to the end of the room, between the other two cords, where it passes over a pulley, and thence returns to a roller under the table. The circle of this roller extends beyond the table; and there, has a wheel fastened to it, from which project three pins, each about four inches long, by pressing on which with the foot, the wheel is turned round, and with it the roller; by means of which, the paper is drawn forward on the cords for a space corresponding with the distance between the pins in the wheel.

The contrivance for giving an extraordinary pressure to the block, consists of a long and a short level, projecting from one side of an axle, placed over head, above the printers' table; which levers and the matters supported by them, are balanced by a weight appended to an arm which proceeds from the other side of the axle. From the long lever a cord falls to the ground, where a treadle is attached to it: a long pole is jointed to the end of the short lever,—descends from it directly over the place of the block, on which it is made to press, by standing on the treadle whenever it is thought proper,—and is put out of the way when not wanted, by placing the end of it behind a piece of wood, which projects upwards, from the back of the table, for that purpose.

ENCAUSTIC PAINTING.

This is an art upon which the ancients highly prided themselves: it consists in fixing by fire the colours made use of by the artist, who employed wax to give them a gloss, and preserve them from being injured by the air.

This ancient art, after having been long lost, was restored by Count Caylus, a member of the Academy of Inscriptions in France; and the method of painting in wax was announced to the Academy of Painting and Belles Lettres, in the year 1753; though M. Bachelier, the author of a treatise De l'Histoire & du Secret de la Peinture en Cire, had actually painted a picture in wax in 1749; and he was the first who com-applied to cloth or paper, through the substance of which the wax may pass; but in wood, stone, metals, or plaster, the method of Count Caylus must be observed.

DCCCXVIII.

METHOD OF FORMING GROUNDS FOR PAINTING WITH *Crayons*; *and of fixing these, as well as Water-colours.*

On the unwaxed side of a linen cloth, stretched and waxed as before, lay an even and thick coat of the colour proper for the ground; having prepared this colour by mixing some proper pigment with an equal quantity of chalk; and tempering them with water. When the colour is dry, bring the picture to the fire that the wax may melt, pass through the cloth, and fix the ground. An additional quantity of wax may be applied to the back part of the picture, if that which was first rubbed on, should not be sufficient for the body of colour; but as this must be laid on without heat, the wax should be dissolved in oil of turpentine, and applied with a brush, and the canvas be again exposed to the fire, that the fresh supply of wax should pass through the cloth, and be absorbed by the colour; and thus a firm and good body will be formed for working on, with the crayons. If cloth and paper are joined together, the cloth must be first fixed to the straining frame, and then the paper must be pasted to it with a composition of paste made of wheaten flour, or starch, and water, and about a twelfth part of its weight of common turpentine. The turpentine must be added to the paste when it is almost sufficiently boiled; the composition is to be well stirred, and left to simmer over the fire for five or six minutes. Let wax be dissolved in oil of turpentine to the consistence of a thin paste; and when the cloth and paper are dry, let them be held near a fire; and with a brush lay a coat of the wax and turpentine on both sides of the joined cloth and paper, to such a degree of thickness, that both surfaces may shine throughout, without any appearance of dull spots. Then expose the cloth to the fire, or to the sun; by which means the oil will evaporate, and the wax become solid, and be fit to receive any composition of colour proper for a ground; which is to be laid on as above directed, in the case of cloth without paper.

Observations. Almost all the colours that are used in oil-painting, may be also applied in the encaustic method. M. Muntz objects, indeed, to brown light pink, and unburnt terra di sienna; because these, on account of their gummy or stony texture, will not admit such a cohesion with the wax, as will properly fix them: but other colours which cannot be admitted in oil-painting, as red lead, red orpiment, crystals of verdigris, and red precipitate of mercury, may be used here. The crayons used in encaustic painting are the same with those used in the common way of crayon painting, excepting those that in their composition are too tenacious. The method of using them is the same in both cases.

The encaustic painting has many peculiar advantages: though the colours have not the natural varnish or shining which they acquire with oil; they have all the strength of paintings in oil, and all the airiness of water colours, without partaking of the apparent character or defects of either: they may be looked at in any light and in any situation, without any false glare: the colours are firm and will bear washing; and a picture, after having been smoked, and then exposed to the dew, becomes as clean as if it had been but just painted. It may also be retouched at pleasure, without any detriment to the colours; for the new colours will unite with the old ones, without spots, as is the case in common size painting: nor is it necessary to rub the places to be retouched with oil as in oil pictures; neither is it liable to crack, but is easily repaired, if it should chance to suffer any injury. The duration of this painting is also a very material advantage; the colours are not liable to fade and change; no damp can affect them, nor any corrosive substance injure them; nor can the colour fall off in shivers from the canvas. However, notwithstanding all these and other advantages, enumerated by the abbe Mazeas and M. Muntz, this art has not yet been much practised. Many of these properties belong to a much higher species of encaustic painting, afterwards discovered in England, the colours of which are fixed by a very intense heat; nor are the colours or grounds, on which they are laid, liable to be dissolved or corroded by any chemical menstruum; nor, like the glassy colours of enamel, to run out of the drawing on the fire. This method is described in the second part of the 49th volume of the Philosophical Transactions.

DCCCXIX.

ENCAUSTIC PAINTING, AS PRACTISED IN ENGLAND.

Notwithstanding the ingenuity of the above operations, we find the ancient, or some similar method of painting in wax, remained a desideratum upwards of twenty-five years; and till, in 1787, a method was communicated to the Society of Arts, by Miss Greenland. The ground of her information she received at Florence, through the acquaintance of an amateur of painting, who procured her the satisfaction of seeing some paintings in the ancient Grecian style, executed by Signora Parenti, a professor of that place, who had been instructed by a Jesuit at Pavia, the person who made the farthest discoveries in that art. Miss Greenland's friend, knowing that she was very fond of painting, informed her what were the materials the paintress used;

but could not tell her the proportions of the composition; however, from her anxiety to succeed in such an acquisition, she made various experiments; and at last obtained such a sufficient knowledge of the quantities of the different ingredients, as to begin, and finish a picture, which she afterwards presented to the society for their inspection.

Her method is as follows. "Take an ounce of white wax, and the same weight of gum mastich powdered. Put the wax in a glazed earthen vessel over a very slow fire; and when it is quite dissolved, strew in the mastich, a little at a time; stirring the wax continually, until the whole quantity of gum is perfectly melted and incorporated. Then throw the paste into cold water, and when it is hard, take it out, wipe it dry, and beat it in a Wedgewood's mortar; observing to pound it at first in a linen cloth to absorb some drops of water that will remain in the paste: these would prevent the possibility of reducing it to a powder, which must be so fine as to pass through a thick gauze. It should be pounded in a cold place, and but a little at a time; as after long beating, the friction will, in a degree, soften the wax and gum, and instead of their becoming a powder they will return to a paste.

"Make strong gum arabic water, and when you paint, take a little of the powder, some colour, and mix them together with the gum water. Light colours require but a small quantity of the powder, but more of it must be put in proportion to the body and darkness of the colours. For black there should be almost as much of the powder as of colour.

"Having mixed the colours, and no more than can be used before they grow dry; paint with clear water, (as is practised in painting with water colours,) a ground on the wood, first painted of some proper colour prepared in the same manner as is described for the picture; walnut-tree and oak are the sorts of wood commonly made use of in Italy for this purpose. The painting should be very highly finished; otherwise, when varnished, the tints will not appear united.

"When the painting is quite dry, with rather a hard brush, passing it one way, varnish it with white wax: this is kept melted in an earthen vessel, over a very slow fire till the picture is varnished, taking great care that the wax does not boil. Afterwards hold the picture before a fire, near enough to melt the wax, but not to make it run; and when the varnish is entirely cold and hard, rub it gently with a linen cloth. Should the varnish blister, warm the picture again very slowly, and the bubbles will subside. When the picture is dirty, it need only be washed with cold water."

Observation. The opinion given by the society upon the above, was, that, "The method made use of by Miss Greenland provides against all inconveniencies; and the brilliancy of the colours in the picture painted by her, and exhibited to the society, fully justified the opinion, that the art of painting in wax, as above described, highly merited the reward of a gold pallet, voted to her on this occasion."

DCCCXX.

ANOTHER METHOD.

Another lady, Mrs. C. J. Hooker, of Rottingdean, near Brighton, laid before the Society of Arts, in 1807, the following method of preparing and applying a composition for painting in imitation of the ancient encaustic painting.

"Put into a glazed earthen vessel four ounces and a half of gum arabic, and eight ounces (or half a pint wine measure) of cold spring water; when the gum is dissolved, stir in seven ounces of gum-mastich, which has been washed, dried, picked, and beaten fine. Set the earthen vessel containing the gum-water, and gum-mastich, over a slow fire; continually stirring and beating them hard with a spoon, in order to dissolve the gum-mastich. when sufficiently boiled, it will no longer appear transparent, but will become opaque, and stiff like a paste. As soon as this is the case, and the gum-water and mastich are quite boiling, without taking them off the fire, add five ounces of white wax, broken into small pieces, stirring and beating the different ingredients together, till the wax is perfectly melted, and has boiled. Then take the composition off the fire, as boiling it longer than necessary, would only harden the wax, and prevent its mixing so well afterwards with water. When taken off the fire, and in the glazed earthen vessel, it should be beaten whilst hot, but not boiling.

Now mix with it, by degrees, a pint (wine measure) of cold spring water, then strain the composition, (as some dirt will boil out of the gum-mastich,) and put it into bottles: the composition, if properly made, should be like a cream, and the colours when mixed with it should be as smooth as oil.

The method of using it, is, to mix with the composition upon an earthen pallet, such colours, in powder, as are used in painting with oil; and such a quantity of the composition is to be mixed with the colours, as to render them of the usual consistency of oil colours; then paint with clear water. The colours, when mixed with the composition, may be laid on, either thick or thin, as may best suit the subject: on which account, this composition is very advantageous, where any particular transparency of colouring is required; but in most cases it answers best, if the colours be laid on thick, and they require the same use of the brush as in painting with body colours, and the same brushes as are used in oil painting. The colours, if grown dry, when mixed with the composition, may be used by putting a little clear water over them; but it is less trouble to put some water when the colours are observed to be growing dry.

In painting with this composition the colours blend without difficulty when wet; and even when dry, the tints may easily be united by means of a brush and a very small quantity of clear water. When the painting is finished, put some white wax into a glazed earthen vessel over a slow fire, and when melted, but not boiling, with a hard brush cover the painting with the wax. When cold take a moderately hot iron, such as is used for ironing linen, and so cold as not to hiss if touched with any thing wet, and draw it lightly over the wax. The painting will appear as if under a cloud, till the wax is perfectly cold; but if, when so, the painting should not appear sufficiently clear, it may be held before the fire, so far from it as to melt the wax but slowly; or the wax may be melted by holding a hot poker at such a distance as to melt it gently; especially such parts of the picture as should not appear sufficiently transparent or brilliant: for the oftener heat is applied to the picture, the greater will be the transparency and brilliancy of colouring; but the contrary effect would be produced if too sudden or too great a degree of heat was applied, or for too long a time; as it would draw the wax too much to the surface, and might likewise crack the paint. Should the coat of wax, put over the painting when finished, appear in any part uneven, it may be remedied by drawing a moderately hot iron over it again, as before mentioned, or even by scraping the wax with a knife: and should the wax, by too great, or by too long an application of heat, form into bubbles at particular places;—by applying a poker heated, or even a tobacco-pipe made hot, the bubbles would subside; or such defects may be removed by drawing any thing hard over the wax, which would close any small cavities. When the picture is cold, rub it with a fine linen cloth.

Observations. Paintings may be executed in this manner, upon wood (first having pieces of wood let in behind, across the grain of wood, to prevent its warping) canvas, card, or plaster of Paris. The plaster of Paris requires no other preparation than mixing some fine plaster of Paris, in powder, with some cold water, to the thickness of a cream; then put it on a looking-glass, having first made a frame of bees-wax of the form and thickness required; when dry take it off, and there will be a very smooth surface to paint upon. Wood and canvas are best covered with some gray tint mixed with the same composition of gum-arabic, gum-mastich, and wax; and with the same sort of colours as before mentioned, before the design is begun, in order to cover the grain of the wood, or the threads of the canvas. Paintings may also be done in the same manner with only gum-water and gum-mastich, prepared in the same way as the mastich and wax; but instead of putting seven ounces of mastich, and when boiling, adding five ounces of wax; mix twelve ounces of gum-mastich with the gum-water, prepared as before mentioned. Before it is put on the fire, and when sufficiently boiled and beaten, and is a little cold, stir in by degrees twelve ounces, or three quarters of a pint of cold spring water, and afterwards strain it.

TRANSPARENCIES.

The effect of this kind of drawing, (though by no means a modern invention,) is very pleasing, if managed with judgment, particularly in fire, and moonlights; where brilliancy of light, and strength of shade, are so very desirable.

The very great expence attending the purchase of stained-glass, and the risk of keeping it secure from accident, almost precludes the use of it in ornamenting rooms; but transparencies form a substitute nearly equal, and at a very small expence.

DCCCXXI.

ART OF MAKING TRANSPARENT PAINTINGS.

The paper must be fixed in a straining-frame, in order to place it between the eye and the light, when required. After tracing the design, the colours must be laid on, in the usual method of stained drawings. When the tints are got in, place the picture against the window, on a pane of glass framed for the purpose, and begin to strengthen the shadows with Indian ink, or with colours, according as the effect requires; laying the colours sometimes on both sides of the paper, to give greater force and depth of colour. The last touches for giving final strength to shadows and forms, are to be done with ivory-black, or lamp-black, prepared with gum-water; as there is no pigment so opaque, and capable of giving strength and decision.

When the drawing is finished, and every part has got its depth of colour and brilliancy, being perfectly dry, touch very carefully with spirits of turpentine, on both sides, those parts which are to be the brightest, such as the moon and fire; and those parts requiring less brightness, only on one side. Then lay on immediately, with a pencil, a varnish, made by dissolving one ounce of Canada balsam in an equal quantity of spirit of turpentine. Be cautious with the varnish, as it is apt to spread. When the varnish is dry, tinge the flame with red-lead and gamboge, slightly touching the smoke next the flame. the moon must not be tinted with colour.

Observations. Much depends upon the choice of the subject; and none is so admirably adapted to this species of effect, as the gloomy Gothic ruin, whose antique towers and pointed turrets finely contrast their dark battlements with the pale yet brilliant moon. The effect of rays passing through the ruined windows, half choked with ivy; or of a fire among the clustering pillars and broken monuments of the choir, round which are figures of banditti, or others, whose haggard faces catch the reflecting light; afford a peculiarity of effect not to be equalled in any other species of painting. Internal views of cathedrals also, where windows of stained glass are introduced, have a beautiful effect.

The great point to be attained is, a happy coincidence between the subject and the effect produced. The fine light should not be too near the moon, as its glare would tend to injure her pale silver light; those parts which are not interesting, should be kept in an undistinguishable gloom; and where the principal light is, they should be marked with precision. Groups of figures should be well contrasted; those in shadow crossing those that are in light, by which means the opposition of light against shade is effected.

PAINTING ON GLASS.

The ancient mode of painting on glass was very simple: it consisted in the mere arrangement of pieces of glass, of different colours, in some sort of symmetry; and constituted what is now called Mosaic work. In process of time more regular designs were attempted, and figures were represented, heightened with all their shades: still the ancients proceeded no farther than the contours of the figures, in black, with water colours; and etched the draperies, after the same manner, on glasses of the colour of the object they designed to paint. For carnation they used glass of a bright red colour; and upon this they drew the principal lineaments of the face, &c. with black. At length, the taste for this sort of painting improving considerably, and the art being found applicable to the adorning of churches, palaces, &c. they found out means of incorporating the colours in the glass itself, by heating them in a fire to a proper degree, having first laid on the colours. A French painter at Marseilles is said to have given the first notion of this improvement, upon going to Rome under the pontificate of Julius II; but Albert Durer, and Lucas of Leyden, were the first that carried it to any perfection. This art, however, has frequently met with much interruption, and has sometimes been almost totally lost.

DCCCXXII.

BLACK.

The colours used in Painting or Staining Glass, are very different from those used in painting either in water, or oil colours. For Black, take scales of Iron, one ounce; scales of Copper, one ounce; Jet, half an ounce: reduce them to powder, and mix them.

DCCCXXIII.

BLUE.

For Blue, take powder of common-blue, one pound; Nitrate of Potass, half a pound; mix them, and grind them well together.

DCCCXXIV.

CARNATION.

For Carnation, take red chalk, eight ounces; iron scales, and litharge of silver, of each two ounces; gum-arabic, half an ounce; dissolve in water, grind altogether for half an hour till stiff, then put the compound in a glass and stir it well, and let it stand for fourteen days.

DCCCXXV.

GREEN.

For Green, take red lead, one pound; scales of copper, one pound; and flint, five pounds: divide them into three parts, and add to them as much Nitrate of Potass; put them into a crucible, and melt them by a strong fire; and when the mass is cold, powder it, and grind it on a slab of porphyry.

DCCCXXVI.

GOLD COLOUR.

For Gold-colour, take Silver, an ounce; Antimony, half an [illegible]: melt them in a crucible; then pound the mass to [illegible] and grind it on a copper plate; add to it of yellow ochre, or brick-dust calcined again, fifteen ounces; and grind them well together with water.

DCCCXXVII.

PURPLE.

For Purple, take minium, one pound; brown stone, one pound; white flint, five pounds: divide them into three parts, and add to them as much Nitrate of Potass as one of the parts; calcine, melt, and grind the compound.

DCCCXXVIII.

RED.

For Red, take jet, four ounces; litharge of silver, two ounces; red chalk, one ounce: powder them fine, and mix them.

DCCCXXIX.

WHITE.

For White, take jet, two parts; white flint, ground on a glass very fine, one part: mix them.

DCCCXXX.

YELLOW.

For Yellow, take Spanish-brown, ten parts; Silver-leaf, one part; Antimony, half a part: put all into a crucible, and calcine them well.

Observations. In all the windows of ancient churches, &c. there are to be seen the most beautiful and vivid colours imaginable, which far exceed any of those used by the moderns; not so much because the secret of making those colours is entirely lost, as that the moderns will not go to the charge of them, nor be at the necessary pains. Those beautiful works, which were made in the glass-houses, were of two kinds.

In some, the colour was diffused throughout the whole substance of the glass. In others, which were by far the most common, the colour was only on one side, scarcely penetrating within the substance above one-third of a line; this however, was more or less according to the nature of the colour, the yellow being always found to enter the deepest. These last, though not so strong and beautiful as the former, were of more advantage to the workmen; because on the same glass, though already coloured, they could shew other kinds of colours where there was occasion to embroider draperies, enrich them with foliages, or represent ornaments of gold, silver, &c.

In order to this, they made use of emery, grinding or wearing down the surface of the glass, till they were got through the colour to the clear glass. This done, they applied the proper colours on the other side of the glass. By these means, the new colours were prevented from running and mixing with the former, when they exposed the glasses to the fire. When the ornaments were to appear white, the glass was only bared of its colour with emery, without tinging the place with any colour at all; and this was the manner by which they wrought their lights and heightenings on all kinds of colour.

The first thing to be done, in order to paint, or stain glass in the modern way, is to design, and even colour the whole subject on paper. Then choose such pieces of glass as are clear, even, and smooth, and proper to receive the several parts. Proceed to distribute the design itself, or the paper it is drawn on, into pieces suitable to those of the glass; always taking care that the glasses may join in the contours of the figures, and the folds of the draperies; that the carnations and other finer parts may not be impaired by the lead with which the pieces are to be joined together. The distribution being made, mark all the glasses as well as papers, that they may be known again: which done, apply every part of the design upon the glass intended for it; and copy or transfer the design upon this glass with the black colour diluted in gum-water, by tracing and following all the lines and strokes that appear through the glass, with the point of a pencil.

When these strokes are well dried, which will be in about two days, (the work being only in black and white,) give it a slight wash over with urine, gum-arabic, and a little black: and repeat this several times, according as the shades are desired to be heightened; with this precaution, never to apply a new wash, till the former is sufficiently dried. This done, the lights and risings are given by rubbing off the colour in the respective places with a wooden point, or by the handle of the pencil.

As to the colours above mentioned, they are used with gum-water, the same as in painting in miniature; taking care to apply them lightly, for fear of effacing the outlines of the design; or even, for the greater security, to apply them on the other side; especially yellow, which is very pernicious to the other colours, by blending therewith. And here too, as in pieces of black and white, particular regard must always be had, not to lay colour on colour, till such time as the former is well dried.

When the painting of all the pieces is finished, they are carried to the furnace to anneal, or to bake the colours.

DCCCXXXI.

Art of Tingeing Glass of various Colours.

Glass is tinged of various colours by mixing with it, while in fusion, some of the metallic oxides; and on this process, well conducted, depends the formation of pastes, or factitious gems.

Blue glass is formed by means of Oxide of Cobalt.
Green, by the Oxide of Iron or of Copper.
Violet, by Oxide of Manganese.
Red, by a mixture of the Oxides of Copper and Iron.
Purple, by the purple Oxide of Gold.
White, by the Oxides of Arsenic and of Zinc.
Yellow, by the Oxide of Silver, and by combustible bodies.

DCCCXXXII.

To make Artificial Pearls.

Take the blay, or bleak fish, which is very common in the rivers near London, and scrape off the fine silvery scales from the belly. Wash and rub these in water. Then suffer this water to settle, and a sediment will be found of an oily consistence. A little of this is to be dropped into a hollow glass bead of a bluish tint, and shaken about, so as to cover all the internal surface. After this, the bead is filled up with melted white wax, to give it solidity and weight.

Enamelling.

The art of enamelling consists in the application of a smooth coating of vitrified matter to a bright polished metallic surface. It is, therefore, a kind of varnish made of glass, and melted upon the substance to which it is applied, affording a fine uniform ground for an infinite variety of ornaments which are also fixed on by heat.

The general principles on which enamelling is founded, are, on the whole, very simple; but, perhaps, there is none of all the chemico-mechanical arts which requires, for the finer parts, a greater degree of practical skill and dexterity, and of patient and accurate attention to minute processes. The concealment observed by those who profess this art, is proportioned to the difficulty of acquiring it; the chemist must, therefore, content himself with the general principles of enamelling, and with the detail of those particulars that are commonly known.

Though the term enamelling is usually confined to the ornamental glazing of metallic surfaces, it strictly applies to the glazing of pottery or porcelain, the difference being only, that in the latter, the surface is of baked clay. With regard to the composition of coloured enamels (which are all tinged by different metallic oxides), a very general account of the substances used will suffice.

The only metals that are enamelled are gold and copper; and with the latter the opaque enamels, only, are used. Where the enamel is transparent and coloured, the metal chosen should not only have its surface unalterable, when fully red-hot, but also be in no degree chemically altered by the close contact of melted glass, containing an abundance of some kind of metallic oxide. This is the chief reason why coloured enamelling on silver is impracticable, though the brilliance of its surface is not impaired by mere heat; for, if an enamel made yellow with oxide of lead, or antimony, be laid on the surface of bright silver, and be kept melted on it for a certain time, the silver and the enamel act on each other so powerfully, that the colour soon changes from a yellow to an orange, and lastly to a dirty olive. Copper is equally altered by the coloured enamels, so that gold is the only metal which can bear the long contact of the coloured glasses at a full red heat, without being altered by them.

DCCCXXXIII.

ENAMEL FOR DIAL-PLATES.

The simplest kind of enamel is that fine white opaque glass, which is applied to the dial-plates of watches. The process of laying on which, is as follows.

A piece of thin sheet-copper, hammered to the requisite convexity, is first accurately cut out, a hole drilled in the middle for the axis of the hands, and both the surfaces made perfectly bright with a brush.

A small rim is then made round the circumference, with a thin brass band rising a little above the level, and a similar rim round the margin of the central hole. The use of these is to confine the enamel when in fusion, and to keep the edges of the plate quite neat and even. The substance of the enamel is a fine white opaque glass; this is bought in lump by the enamellers, and is first broken down with a hammer, then ground to a powder sufficiently fine, with some water, in an agate mortar; the superfluous water being then poured off, the pulverized enamel remains of about the consistence of wetted sand, and is spread very evenly over the surface of the copper-plate. In most enamellings, and especially on this, it is necessary also to counter-enamel the under concave surface of the copper-plate, to prevent its being drawn out of its true shape, by the unequal shrinking of the metal, and enamel, on cooling. For this kind of work, the counter-enamel is only about half the thickness on the concave, as on the convex side. For flat plates, the thickness is the same on both sides.

The plate, covered with the moist enamel powder, is warmed and thoroughly dried, then gently set upon a thin earthen ring, that supports it only by touching the outer rim, and put gradually into the red hot muffle of the enameller's furnace. This furnance is constructed somewhat like the assay-furnace, but the upper part alone of the muffle is much heated, and some peculiarities are observed in the construction, to enable the artist to govern the fire more accurately. See Plate 8.

The precise degree of heat to be given here, as in all enamelling, is that at which the particles of the enamel run together into an uniform pasty consistence, and extend themselves evenly, shewing a fine polished face; carefully avoiding, on the other hand, so great a heat as would endanger the melting of the thin metallic plate. When the enamel is thus seen to *sweat down*, as it were, to an uniform glossy glazing, the piece is gradually withdrawn and cooled, otherwise it would fly by the action of the cold air.

DCCCXXXIV.

SECOND COATING WITH DIVISION MARKS.

A second coating of enamel is then laid on and fired as before; but this time, the finest powder of enamel is taken, or that which remains suspended in the washings. It is then ready to receive the figures and division marks, which are made of a black enamel, ground in an agate mortar, to a most impalpable powder, worked up, on a pallet, with oil of lavender, and laid on with an extremely fine hair brush. The plate is then stoved to evaporate the essential oil, and the figure is burnt in, as before. Polishing with tripoli, and minuter parts of the process, need not be here described.

Observations. If the enamel be chipped off a dial plate (which may be done with the utmost ease, by bending it backwards and forwards, as the adhesion between the metal and glazing is very slight) the part immediately in contact with the copper, will be found deeply and nearly uniformly browned, which shews how unfit copper alone would be for the transparent enamels.

The regulation of the fire appears to be the most difficult of all the parts of this nice process, particularly in the fine enamelling of gold for ornamental purposes, for designs, miniatures, and the like; where three, four, or sometimes five separate firings are required. If the heat is too low, the enamel does not spread and vitrify as it ought; if too high, it may be enough to melt the metal itself, whose fusing point is but a small step above that of the enamel, or else (what is an equal mortification to the artist) the delicate figures, laid on with so much care and judgement, melt down in a moment; and the piece exhibits only a confused assemblage of lines, and fragments of designs.

DCCCXXXV.

COMPOSITION OF THE WHITE ENAMEL.

The exact composition of the opaque white enamel, is a matter of considerable importance. A good enamel of this kind, fit to be applied to porcelain and metals, should be of a very clear fine white, so nearly opaque, as only to be translucent at the edges; and at a moderate red heat it should run into that kind of paste, or imperfect fusion, which allows it to extend itself freely and uniformly, and to acquire a glossy even surface, without, however, fully melting into a thin glass. The opaque white of this enamel is given by the and then ground to powder), and eight ounces of salt of tartar; melt the mixture in a strong fire kept up for ten hours, after which reduce the mass to powder. This is the common material for the opaque enamels, and is of a grey white colour. To make this fine enamel quite white, mix six pounds of the compound with 48 grains of the best black Oxide of Manganese, and melt in a clear fire. When fully fused, throw it into cold water, then re-melt and cool, as before, two or three times, till the enamel is quite white and fine.

Observation. Kunckel observes on this process, that he tried it without the oxide of manganese, but the enamel, instead of being milk white, was blueish and not good; so that there is no doubt but that this oxide is highly important. If too much is used, the enamel becomes of a rose purple.

DCCCXXXVII.

ENAMEL OF A RICH RED COLOUR.

Coloured enamels are composed of a common basis, which is a fusible mixture of vitrifiable materials, and of some metallic oxide. In general, the coloured enamels are required to be transparent, in which case, the basis is a kind of glass, composed of Borax, Sand, and Oxide of Lead, or other vitrescent mixtures; in which the proportion of saline, or metallic flux, is more or less according to the degree of heat that the colouring oxide will bear without decomposition. When the coloured enamel is to be opaque, or opalescent, a certain portion of the white opaque enamel, or of the Oxide of Tin, is added to the mixture. The most beautiful and costly colour known in enamelling, is an exquisitely fine rich red, with a purplish tinge, given by the salts and oxides of gold; especially by the purple precipitate, formed by tin in one form or other; and by Nitro-Muriate of Gold; and also by the fulminating gold. This beautiful colour requires much skill in the artist, to be fully brought out. It is said, that when most perfect, it should come from the fire quite colourless, and afterwards receive its colour by the flame of a candle. Gold colours will not bear a violent fire.

Observation. Other, and common reds, are given by the oxide of iron; but this requires the mixture of alumine, or some other substance refractory in the fire, otherwise at a full red heat, the colour will degenerate into black.

in contact with the colour when red hot, which might affect its degree of oxidation, and thence the shade of colour which it is intended to produce. As the colour of some vitrified metallic oxides (such as that of gold) will stand at a very moderate heat, whilst others will bear, and even require a higher temperature to be properly fixed, it forms a great part of the technical skill of the artist to supply the different colours in proper order; fixing first those shades which are produced by the colours that will endure the highest, and finishing with those that demand the least heat. The outline of the design is first traced on the enamel, ground and burnt in; after which, the parts are filled up gradually by repeated burnings, to the last and finest touches of the tenderest enamel.

Transparent enamels are scarcely ever laid upon any other metal than gold, on account of the discoloration produced by other metals, as already explained. If, however, copper is the metal used, it is first covered with a thin enamel coating, over which gold leaf is laid and burnt in, so that, in fact, it is still this metal that is the basis of the ornamental enamel. With regard to the vast number of important minutiæ in the selection and order of applying the colours, the management of the fire, &c. &c. almost the whole of what is known, on this subject, is confined to the practical artist.

DCCCXLII.

MANUFACTURE OF MOSAIC AT ROME.

It is well known that Mosaic-work consists of variously shaped pieces of coloured glass enamel; and that when these pieces are cemented together, they form those regular and other beautiful figures which constitute tessellated pavements. These pavements, the work of the ancient Romans, have frequently been dug up in England and other countries. The principal manufactory of Mosaic pictures in the present day, is at Rome, and belongs to his Holiness the Pope.

The building in which the establishment is situated is large, and contains a collection of enamels drawn into the form of sticks. These are arranged, according to their colours, in an extensive suit of rooms. The number of shades of colour is 17,000.

The enamel, consisting of glass mixed with metallic colouring matter, is heated for eight days in a glass-house, each colour in a separate pot. The melted enamel is taken out with an iron spoon, and poured on polished marble placed horizontally; and another flat marble slab is laid upon the surface, so that the enamel cools into the form of a round cake, of the thickness of $\frac{3}{10}$ths of an inch.

In order to divide the cake into smaller pieces, it is placed on a sharp steel anvil, called Tagliulo, which has the edge uppermost; and a stroke of an edged hammer is given on the upper surface of the cake, which is thus divided into long parallelopipeds, or prisms, whose bases are $\frac{3}{10}$ths of an inch square. These parallelopipeds are again divided across their length by the tagliulo and hammer into pieces of the length of $\frac{8}{10}$ths of an inch, to be used in the Mosaic pictures. Sometimes the cakes are made thicker, and the pieces larger.

For smaller pictures, the enamel, whilst fused, is drawn into long parallelopipeds, or quadrangular sticks; and these are divided across by the tagliulo and hammer, or by a file; sometimes, also, these pieces are divided by a saw without teeth, consisting of a copper blade and emery; and the pieces are sometimes polished on a horizontal wheel of lead with emery.

Gilded Mosaic is formed by applying the gold-leaf on the hot surface of a brown enamel, immediately after the enamel is taken from the furnace; the whole is put into the furnace again for a short time, and when it is taken out, the gold is firmly fixed on the surface. In the gilded enamel, used, in Mosaic, at Rome, there is *a thin coat of transparent glass* over the gold.

Observations. The ancient Romans, besides the enamel for mosaic, made other works in enamel. Winklemann mentions ancient tiles of a kind of glass or enamel, for paving the floors of rooms; and he describes a small picture composed of filaments of enamel of different colours, agglutinated together by fusion, each transverse section of this gave a picture like that at the extremity. The antique pastes, or artificial gems, are also products of art allied to enamel.

Anciently, the paste in which the pieces of mosaic were imbedded, called in Italy stucco, was composed of a measure of quick-lime quenched in water, and three measures of pounded marble; these were made into a mass with water and white of eggs; and this was called Marmoratum: but this paste hardens too rapidly, so that it is hard before the workman has time to insert the pieces, and it is injured by damp more readily than the cement made with oil.

The paste now used, is composed of a measure of quenched quick-lime, and three measures of powdered travertine stone: these are mixed with linseed oil, and are stirred and worked up every day with a trowel. The mass is at first level on the surface, but afterwards swells up. Each day some oil is added, to prevent the mass from becoming dry and intractable. The mass is ready in a shorter time in warm weather than in cold; in summer the mass is at its perfection in twenty days; this is known from its ceasing to swell, the water that was in the lime having evaporated; the mass is then uniform throughout, like an ointment. In winter, and when the air is moist, it requires a month to bring the paste to perfection.

The wall to which the mosaic is to be applied, must have the lime taken off its surface; then furrows an inch deep are formed on the wall, to fix the cement. For the same purpose large-headed nails are driven in, and wire is stretched from one nail to another. After this, the wall thus prepared, is painted over with linseed oil. Then the cement is laid on, to the extent of a surface of as many palms as can be executed before the cement dries. The plasticity and softness of the cement lasts about twenty days; after that the oil exudes, and the lime and travertine become a hard mass. The cement made with linseed oil is yellow; that made with white of eggs is white, and the white cement is considered to be a character for distinguishing the old mosaic from the modern; but some of the modern is also made with white cement.

DCCCXLIII.

Muriate of Lead; or Patent Yellow.

This pigment is prepared by triturating minium of red Oxide of Lead, and common Salt together, and then exposing them in a crucible to a gentle heat. In this process the salt is decomposed, the acid unites with the Oxide of Lead, and forms the Patent Yellow. The alkaline base of the salt remains in the compound, which is to be carefully washed and crystallized.

Observation. Muriate of Lead tinges vitreous matters of a yellow colour. Hence the beautiful glazing given to Queen's Ware. It is composed of 80 lbs. of muriate of lead, and 20 lbs. of flints ground together very fine, and mixed with water till the whole becomes as thick as cream. The vessels to be glazed are dipped in the glaze, and suffered to dry, when they are exposed to a sufficient degree of heat to vitrify the surface.

DCCCXLIV.

To prepare the Purple Precipitate of Cassius.

Dissolve some pure Gold in Nitro-Muriatic Acid; adding either Acid, or Metal, until saturation takes place. Now dissolve some pure Tin in the same kind of Acid; observing the same point of saturation as with the Gold; and pour it into the solution of Gold. A purple powder will be precipitated, which must be collected and washed in distilled water.

Observation. This beautiful purple colour, as before mentioned, is extremely useful to enamellers, and to glass-stainers.

DCCCXLV.

To make Artificial Coral for Grottoes.

To two drams of fine Vermillion add one ounce of clear Resin, and melt them together. Having the branches of municate to flame various colours, it has hitherto been possible to introduce only a very few colours into that of gunpowder.

To make white fire, the gunpowder must be mixed with Iron, or rather Steel, filings.

To make red fire, Iron-sand must be employed in the same manner.

As Copper filings, when thrown into a flame, render it green, it might be concluded, that if mixed with gunpowder, it would produce a green flame; but this experiment does not succeed. It is supposed that the flame is too ardent, and consumes the inflammable part of the Copper too soon. But it is probable that a sufficient number of trials have not yet been made; for is it not possible to lessen the force of gunpowder in a considerable degree, by increasing the dose of the Charcoal?

Camphor mixed with the composition, makes the flame to appear of a pale white colour.

Raspings of Ivory give a clear flame of a silver colour, inclining a little to that of lead; or rather a white dazzling flame.

Greek pitch produces a reddish flame, of a bronze colour.

Black pitch, a dusky flame, like a thick smoke, which obscures the atmosphere.

Sulphur, mixed in a moderate quantity, makes the flame appear blueish.

Sal-ammoniac and Verdigris give a greenish flame.

Raspings of yellow Amber communicate to the flame a lemon colour.

Crude Antimony gives a russet colour.

DCCCXLIX.

INK POWDER.

Common liquid Ink is not easily transported from one place to another; and, besides this inconvenience, it is apt to dry in the ink-holder. In bottles, unless well corked, it becomes decomposed and evaporates; and if the bottles happen to break, it may spoil clothes, or any other article near it. For the convenience, therefore, of those who travel either by land or by sea; Ink-powder has been invented. This is nothing else than the substances employed in the composition of common Ink, pounded and pulverized; so that it can be instantaneously converted into Ink by mixing it up with a little water.

DCCCL.

China Ink.

China or Indian Ink, which is employed for small drawings and plans, may easily be made by the following process. Take the kernels of the stones of Apricots, and burn them in such a manner as to reduce them to powder, but without producing flame, which may be done by wrapping up a small packet of them in a piece of tinned iron, and tying round it a bit of iron wire. Put this packet into an oven, heated to the same degree as that required for baking bread: the kernels will be reduced to a sort of Charcoal; with which an Ink may be made similar to that brought from China.

Pound this Charcoal in a mortar, and reduce it to an impalpable powder, which must be finely sifted. Now form a pretty thick solution of gum-arabic in water, and, having mixed it with the powder, grind the whole on a stone, in the same manner as colour-men grind colours. Nothing further is necessary, but to put the paste into some small moulds, formed of cards, and rubbed over with white wax, to prevent it from adhering to them.

Observations. In regard to the smell of the China ink, it arises from a little musk, which the Chinese add to the gum-water, and may easily be imitated. The figures seen on the sticks of China ink, are the particular marks of the manufacturers, who, as in all other countries, are desirous of distinguishing whatever comes from their hands.

Dr. Lewis thinks, from the information of Father du Halde, that China ink is composed of nothing but lamp black and animal glue. Having boiled a stick of China ink in several portions of water, in order to extract all the soluble parts; and having filtered the different liquors, which he evaporated in a stone vessel, he found that they had the same odour as glue, and that they left, after evaporation, a pretty considerable quantity of a tenacious substance, which seemed to differ in nothing from common glue.

DCCCLI.

Indestructible Inks, for resisting the Action of *Corrosive Substances.*

On many occasions, it is of importance to employ an Ink indestructible by any process, that will not equally destroy the material on which it is applied. For Black Ink, 25 grains of Copal, in powder, are to be dissolved in 200 grains of Oil of Lavender, by the assistance of gentle heat; and are then to be mixed with 2½ grains of Lamp Black, and half a grain of Indigo: for Red Ink use 120 grains of Oil of Lavender, 17 grains of Copal, and 60 grains of Vermillion. A little Oil of Lavender, or of Turpentine, may be added, if the Ink be found too thick. Mr. Sheldrake suggests, that a mixture of genuine Asphaltum dissolved in Oil of Turpentine, Amber Varnish, and Lamp Black, would be still superior.

This Ink is particularly useful for labelling phials, &c. containing chemical or corrosive substances.

DCCCLII.

READY METHOD OF PRODUCING A FAC-SIMILE OF ANY *Writing.*

The Pen should be made of Glass-Enamel; the point being small and finely polished; so that the part above the point may be large enough to hold as much, or more Ink than a common writing Pen.

A mixture of equal parts of Frankfort Black, and fresh Butter, is now to be smeared over sheets of Paper, and is to be rubbed off after a certain time. The paper, thus smeared, is to be pressed for some hours; taking care to have sheets of blotting-paper between each of the sheets of black paper. When fit for use, writing paper is put between sheets of blackened paper, and the upper sheet is to be written on, with common ink, by the glass or enamel pen. By this method, not only the copy is obtained on which the pen writes, but also, two, or more, made by means of the blackened paper.

DCCCLIII.

COLOURED INKS.

Few of these are now used, with the exception of Red Ink. The preparations are simple, being decoctions of dyeing or colouring materials in water, thickened with Gum Arabic; or being composed of coloured metallic Oxides or insoluble powders, merely diffused in Gum-water. The proportion of Gum Arabic to be used, may be the same as for black writing Ink. All that applies to the fixed or fugitive nature of the several articles used in dyeing, may be applied, in general, to the use of the same substances as Inks.

Red Ink is usually made by boiling about two ounces of

Brazil Wood in a pint of Water, for a quarter of an hour; and adding to the decoction, the requisite quantity of Gum, and about half as much Alum. The Alum both heightens the colour, and makes it less fugitive. Probably a little Madder would make it more durable.

Blue Ink may be made by diffusing Prussian blue, or Indigo, through strong Gum-water.

Yellow Ink may be made by a solution of Gamboge in Gum-water.

The common water-colour cakes, diffused in Water, will make sufficiently good coloured Inks for most purposes.

Inks of other colours may be made from a strong decoction of the ingredients used in dyeing, mixed with a little Alum and Gum Arabic. For example, a strong decoction of Brazil-wood, with as much Alum as it will dissolve, with a little Gum, forms a good red Ink. In this process, a *lake* is formed; and its precipitation is retarded by the Gum.

Observations. Many are the coloured inks which have been written with in ancient and modern times. Golden ink was used by various nations, as may be seen in several libraries, and in the archives of churches. Scarlet ink, made of vermillion, is frequently found in the ancient MSS. but none are found written entirely with ink of that colour. The capital letters are made with a kind of varnish, which seems to be composed of vermillion and gum. Green ink was rarely used in charters, but often in Latin MSS. especially in those of the latter ages: the guardians of the Greek emperors made use of it, in signatures, till the latter were of age. Blue or yellow ink was seldom used but in MSS. The yellow has not been in use, as far as can be learned, for six hundred years.

Metallic and other characters were sometimes burnished. Wax was used as a varnish by the Latins and Greeks; but much more by the latter, with whom it continued a long time. This covering, or varnish, was very frequent in the ninth century.

DCCCLIV.

PERMANENT INK FOR MARKING LINEN.

This useful Ink is composed of Nitrate of Silver (Lunar Caustic); and Tincture, or Infusion of Galls; in the proportions of one dram of the former in a dry state, to two drams of the latter. The Linen, Cotton, or other fabric, must be first wetted with the following liquid, viz. Salt of Tartar, one ounce, dissolved in one ounce and a half of Water; and must be perfectly dry before any attempt is made to write upon it.

DCCCLV.

CURIOUS METHOD OF FORMING PICTURES BY *Nitrate of Silver.*

It is well known that Light has a powerful effect upon many of the Metallic Oxides, causing them to turn black. Mr. J. Wedgewood, availed himself of this property for copying paintings on Glass, and making profiles of figures by means of Nitrate of Silver.

Cover white Paper, or Leather, with a solution of Nitrate of Silver, and place it behind a painting on Glass, which is exposed to the rays of the sun. The rays that come through will blacken the Paper; but the shades will be more or less deep, in proportion to the quantities of Light transmitted through the different parts of the Glass. Where the Glass is transparent, and all the light comes through, the Paper will be quite black; where the Glass is quite opaque, and does not transmit any light, the Paper will be quite white; and there will be degrees of intensity of the shadow, of every variety between these.

Observations. This picture is not sensibly affected by the light of candles or lamps; but the day-light destroys it very soon, causing all the paper to become black; nor have any means, hitherto tried, for preventing this been successful. Besides the application of this property of nitrate of silver to copying the light and shadow of paintings on glass, it may be applied to some others. By means of it delineations may be made of all such objects as are partly opaque and partly transparent. The fibres of leaves, and the wings of insects, may be pretty accurately represented by it; by only making the solar rays pass through them, upon prepared leather or paper. Sir. H. Davy found, that the images of small objects, produced by means of the solar microscope, may be copied without difficulty on this prepared paper. He found that the best proportion was one part of nitrate, to about ten of water. This is sufficient to enable the paper to become tinged, without hurting its texture.

SYMPATHETIC INKS.

Sympathetic Inks are such as do not appear after they are written with, but which may be made to appear at pleasure, by certain means to be used for that purpose. A variety of substances have been used as Sympathetic Inks: among which, are the following:

DCCCLVI.

NITRO-MURIATES OF GOLD AND TIN.

Write with a solution of Gold in Aqua Regia, and let the paper dry gently in the shade. Nothing will appear; but draw a sponge over it, wetted with a solution of Tin in Aqua Regia, the writing will immediately appear of a purple colour.

DCCCLVII.

GALLATE OF IRON.

Write with an infusion of galls, and when the writing is required to appear, dip it into a solution of Sulphate of Iron: the letters will appear black.

DCCCLVIII.

NITRO-MURIATE OF COBALT.

Pulverise one ounce of Cobalt and pour over it four ounces of Nitric Acid in a retort. Digest in a sand-bath for six hours. One ounce of Muriate of Soda diluted in four ounces of Water must now be added; filter and preserve the compound. When to be used, it must be diluted with three times its bulk of distilled Water, to prevent corrosion of the paper.

Observations. The nitric acid, alone, will answer the purpose without the muriate of soda. The salt here obtained is seldom a pure salt of cobalt, as iron is so often combined with it; the solution of cobalt and iron is *green* when exposed to heat: but when a pure blue is wished for, the oxide of cobalt must be precipitated by pure potass, which redissolves the oxide of cobalt and answers as a sympathetic ink. This is of a red colour before it is written with, and blue after.

DCCCLIX.

PRINTERS' INK.

Ten, or twelve, gallons of Nut-oil are set over the fire, in a large iron pot, and brought to boil. It is then stirred with an iron ladle; and whilst boiling, the inflammable vapour arising from it either takes fire of itself, or is kindled, and is suffered to burn in this way for about half an hour: the pot being partially covered, so as to regulate the body of the flame, and, consequently, the heat communicated to the oil. It is frequently stirred during this time, that the whole may be heated equally; otherwise, a part would be charred and the rest left imperfect. The flame is then extinguished by entirely covering the pot. The oil, by this process, has much of its unctuous quality destroyed, and, when cold, is of the consistence of soft turpentine: it is then called Varnish. After this, it is made into Ink, by mixture with the requisite quantity of lamp-black; of which, about two ounces and a half are sufficient for sixteen ounces of the prepared oil. The oil loses, by the boiling, about an eighth of its weight, and emits very offensive fumes. Several other additions are made to the oil during the boiling, such as crusts of bread, onions, and sometimes turpentine. These are kept secret by the preparers. The intention of them is more effectually to destroy part of the unctuous quality of oil; to give it more body to enable it to adhere better to the wetted paper, and to spread on the types neatly and uniformly.

Besides these additions, others are made by the printers, of which the most important is generally understood to be a little fine Indigo in powder, to improve the beauty of the colour.

Observations. Printers' ink is a very singular composition, partaking much of the nature of an oil varnish, but differing from it in the quality of adhering firmly to moistened paper; and in being, to a considerable degree, soluble in soap-water.

It is, when used by the printers, of the consistence of rather thin jelly; so that it may be smeared over the types readily and thinly, when applied by leathern cushions, and rollers; and it dries very speedily on the paper, without running through to the other side, or passing the limits of the letter.

Red printer's ink, is made by adding to the varnish, about half its weight of vermillion. A little carmine also improves the colour.

DCCCLX.

Copper-plate Printer's Ink.

Ink for the rolling-press is made of Linseed Oil, burnt in the same manner as that for common printing Ink; and is then mixed with Frankfort-black, finely ground. There are no certain proportions which can be determined in this kind of Ink; every workman adding oil, or black, to his Ink, as he thinks proper, in order to make it suit his purpose. Some, however, mix a portion of common boiled oil which has never been burnt: but this must necessarily be a bad practice, as such oil is apt to go through the paper; a fault very common in prints, especially if the paper is not very thick. No soap is added; because the Ink is not cleared off from the copper-plates, with Alkaline ley, as in common printing, but with a brush dipped in oil

DCCCLXI.

LITHOGRAPHY; OR PRINTING FROM STONE.

A very ingenious process has of late years been employed to answer, at the same time, both the purposes of designing and engraving; or, in other words, to produce an engraving by the art of designing. This art is called *Lithography*, or *Stone Engraving;* and among the German artists, *chemische druckery*, or *chemical printing*. It consists in being provided with a few slabs of marble, about the size of Dutch tiles, or larger, according to the intended dimensions of the print; the thickness should be about two inches.

The landscape, or other subject, is then to be traced over with a pencil; and the pencilled lines are to be afterwards at leisure retraced with a particular ink which was at first a great secret. It is now, however, known to consist of a solution of Shell-lac in Potass, coloured black by soot from burning wax. When the design has been gone over with this ink, it is left to dry, which commonly takes about two hours, though this will depend upon the temperature and dryness of the atmosphere. The face of the marble being, after this process, washed with Nitric Acid, more or less diluted, according to the degree of relief desired, the whole surface will be corroded, *except where defended by the resinous ink*. The operation is now completed; and to obtain printed copies, nothing more is necessary than to wash the marble clean; to distribute over it, by means of printer's balls, an ink similar to that commonly used by printers; and to press down upon the design, by a roller, or copper-plate press, a sheet of paper properly disposed in a frame.

DCCCLXII.

BLACKING-BALLS FOR SHOES.

Take mutton suet, 4 ounces; bees'-wax, one ounce; sweet oil, one ounce; sugar-candy and gum-arabic, one dram each, in fine powder: melt these well together over a gentle fire, and add thereto about a spoonful of turpentine, and lamp black sufficient to give it a good black colour. While hot enough to run, make it into a ball, by pouring the liquor into a tin mould; or let it stand till almost cold: or it may be moulded by the hand.

DCCCLXIII.

LIQUID JAPAN BLACKING.

Take 3 ounces of Ivory-black, 2 ounces of coarse Sugar, one ounce of Sulphuric Acid, one ounce of Muriatic Acid, one lemon, one table-spoonful of sweet oil, and one pint of vinegar.—First mix the ivory black and sweet oil together, then the lemon and sugar, with a little vinegar to qualify the blacking; then add the Sulphuric and Muriatic Acids, and mix them all well together.

Observation. The sugar, oil, and vinegar, prevent the acids from injuring the leather, and add to the lustre of the blacking.

DCCCLXIV.

CHEAP METHOD.

Ivory black, two ounces; brown sugar, one ounce and a half; and sweet oil, half a table-spoonful.—Mix them well, and then gradually add half a pint of small beer.

DCCCLXV.

ANOTHER METHOD.

A quarter of a pound of ivory black, a quarter of a pound of moist sugar, a table-spoonful of flour, a piece of tallow about the size of a walnut, and a small piece of gum arabic. —Make a paste of the flour, and whilst hot, put in the tallow, then the sugar, and afterwards mix the whole well together in a quart of water.

BLEACHING.

The art of bleaching is of great antiquity.—The ancients were acquainted with the detersive quality of some kinds of clay, and the effects produced by the action of the atmosphere, moisture, and light, on the stuffs exposed to them. Health and cleanliness rendered it necessary to devise quicker methods than these; and the properties of soaps, and leys of wood-ashes were therefore soon discovered.

In the present age the arts have taken advantage of processes and detersive menstrua, the existence of which was before unknown; these discoveries have succeeded each other with such rapidity, that the last twenty years have effected a complete revolution in the art of bleaching.

This art is naturally divided into two distinct branches; the bleaching of vegetable and of animal substances. These being of very different natures, require different processes for whitening them. Vegetables consist of Oxygen, Hydrogen, and Carbon, of which the latter is in the greatest proportion; while animal substances, besides these, contain also a large quantity of Azote, and also Phosphorus and Sulphur.

BLEACHING OF FLAX AND HEMP.

If fine flax is examined, it will be found to be composed of fibres or filaments united together by the sap, enveloping a semi-ligneous substance, and covered by a thin bark. It is the fibrous part only that is used for making cloth, and it must therefore be previously separated from the other matters.

The sap, or succulent part, is composed of extractive principle and water, and the first process is to separate this substance, which holds the filaments together. As soon as the flax is pulled, it is steeped in soft water until the putrefactive fermentation takes place. This degree of fermentation begins with the succulent part, as being more susceptible of decomposition than the rest. Was the flax to be continued long in this state, the whole substance of it would be decomposed or destroyed; upon the same principle that malt is injured by too long steeping, or that wort loses its substance by too long a fermentation. It must therefore be taken out of the water while yet green, and before the whole of its sap is separated. Well-water, and brackish water, must be carefully avoided, as well as that which flows over a gypseous soil. Such waters accelerate putrefaction, and hurt the quality of the hemp and flax.

The flax, when taken from the water, is spread out upon the grass to dry. During the fermentation and decomposition which thence result, there is a speedy combination of oxygen and carbon. Exposure on the grass facilitates the escape of the carbonic acid into the atmosphere, and the plants become of a whitish grey colour.

It is known that a ley, very slightly alkaline, may be substituted with advantage, for this long and noxious operation: it is therefore certain, that a chamber from twenty to thirty feet in length, into which the steam of alkaline caustic water, (of the strength of one-fourth of a degree only,) is introduced, will be sufficient to produce the same effect as watering on an immense quantity of hemp and flax, suspended on basket-work: and that, too, in less time, and with less expense than are required from the different manipulations of watering. The losses occasioned by the negligence of workmen, who, by suffering the hemp and flax to macerate too long, give time to the decomposition to reach the filaments, which renders them brittle, and occasions a considerable waste, will also be avoided. In this process, the artist can follow every moment the progress of his operation, and stop it at the favourable period.

Nothing now remains but the wood, and the flax or fibrous part. The wood is a hollow tube covered over very compactly with the flax. To separate the wood, it must be kiln-dried, in order to render it frangible or brittle; but care must be taken not to apply too much heat, for fear of injuring the flax.

It is next to be beaten or broken, by which means the flax is not only divided into small fibres, but most of the wood is separated, and the part which adheres is reduced to small fragments. To separate these again, the flax is to be thrashed, in small parcels at a time, either by manual labour, or mills contrived for the purpose. Hackling is the last process; which is drawing or combing the flax in small parcels at a time, through a pile or group of polished and sharp iron spikes, placed firmly in wood through an iron-plate.

The linen, as it comes from the loom, is charged with what is called *the weaver's dressing*, which is a paste of flour boiled in water; and as this is brushed into the yarn of the warp before it is woven, it is somewhat difficult to separate it when dry. To discharge this paste, the linen must be steeped in water for about forty-eight hours, when this extraneous substance undergoes a kind of fermentation; this does not extend to the substance of the linen itself, upon the same principle that the green sap is disengaged from the flax without injury to its texture.

When the linen is well washed after this last process, it contains nothing that water can separate; it is of a greyish-white colour, although the fibres of which it is composed, when divested of every adventitious substance, are naturally very white.

The matter which thus colours the linen, is of a resinous nature, insoluble in water, and from its intimate union or dissemination through the very fibres of the flax, is difficult of separation, even by those substances which have a solvent power over it.

To disengage it, however, in as cheap and expeditious a manner as possible, without injuring the texture of the fabric, is the sole object of the process of bleaching.

DCCCLXVI.

BLEACHING BY MEANS OF POTASS.

Potass is the first menstruum which should be used in bleaching. It is most economical to render it caustic. This is done by adding quicklime to the mild Potass, the former having a stronger affinity for the Carbonic Acid than the latter. But care must be taken not to use the alkali too strong, otherwise it will attack and destroy the fibrous part. The Potass, from its solvent power over the colouring matter, dissolves and separates the parts immediately exposed to its action; that is, the part of it which rests superficially upon the fibres of the flax or thread; for it requires ten or twelve repeated boilings, at least, with the alternate agency of the atmosphere, to separate the whole of the resin

Observations. It might be asked, why such an active solvent as potass should not carry away the whole of the resin at once, or at least as much as it alone could in any way separate. This requires an explanation. What appears to us to be a single ultimate fibre of flax in grey linen, is composed of a bundle of minute filaments, closely cemented

All vegetable colours are attacked by this Acid, and whitened with more or less celerity, which depends on their greater or less facility of combining with Oxygen. The colouring matter undergoes a slow action, which terminates by the formation of Carbonic Acid, which, escaping under the form of elastic fluid, produces what we call bleaching

Observations. In whatever manner the oxygenated muriatic acid is procured, it is evident that the oxygen adheres to it only weakly; and it is on this property that the possibility depends of producing speedily, in manufactories, that action which the atmosphere produces but slowly, and of bleaching in a space of time proportionally short.

The oxygenated muriatic acid is employed in four different ways for the purpose of bleaching; first, in the state of gas alone; secondly, in the state of gas combined with water, or what is called the acid: thirdly, potass is mixed with the acid to condense the gaseous vapour and destroy its suffocating odour; fourthly, oxygenated muriates, dissolved in water, are employed.

The first method, viz. employing the gas, was never used but for the purpose of experiment; as the vapour is of so noxious a quality, that to breath it is fatal, and several people fell a sacrifice to their attempts in employing it.

When condensed in water, or in the state of oxygenated muriatic acid, it was found inconvenient in the large way, on account of the expence and difficulty in constructing the necessary apparatus, and the suffocating vapour which escaped.

For the discovery of the oxygenated muriatic acid, its effects on colouring matter, and its inestimable advantages, the arts are indebted to the celebrated Scheele. M. Berthollet lost no time in applying this curious and highly interesting substance to the most important practical uses. His experiments on bleaching by oxygenated muriatic acid, proved completely successful, and he did not delay to communicate his valuable labours to the public. The new method of bleaching was quickly and successfully introduced into the manufactories of Manchester, Glasgow, Rouen, Valenciennes, and Courtray; and it has since been gradually adopted in almost all parts of Great Britain, Ireland, France, and Germany. The advantages that result from this method, which accelerates the process of whitening cottons, linens, paper, &c. to a surprising degree, in every season of the year, can be justly appreciated by commercial people only, who experience its beneficial effects in many ways, but particularly in the quick circulation of capital.

To save the expence of first preparing the muriatic acid, the usual practice is to mix with the oxide of manganese, muriate of soda or common salt, and sulphuric acid diluted with water. The sulphuric acid acts upon the salt, and disengages from it the muriatic acid, which is oxygenated by the oxide of manganese. The proportions observed when cotton is to be bleached, are,

Manganese, -	30 parts
Common salt,	80
Sulphuric acid,	60
Water, -	120

For Linen-cloth the proportions are as follow:

Manganese,	-	60 parts
Salt,	- -	60
Sulphuric acid,		50
Water,	-	80.

The better these substances are combined together, the more easily will the acid gas be disengaged by the action of the sulphuric acid.

DCCCLXVIII.

TO BLEACH LINEN, &c. BY THE OXY-MURIATIC ACID.

To ascertain the strength of this Acid for bleaching, a solution of Indigo in the Sulphuric Acid is employed. The colour of this is destroyed by the Oxygenated Muriatic Acid; and according to the quantity of it that can be discoloured by a given quantity of the liquor, its strength is known.

Cloth is prepared for immersion in Oxygenated water, by soaking in a ley weak potash, and rinsing it afterwards in a large quantity of water, in order to free it completely from the weaver's dressing, and the saliva of the spinners.

In this country, machinery is employed for rinsing and beating; the apparatus must be arranged according to the objects to be bleached; the skeins of thread must be suspended in the tub destined for them, and the cloth must be rolled upon reels in the apparatus. When every thing is thus disposed, the tubs are filled with Oxygenated Muriatic Acid, by introducing a funnel, which descends to the bottom of the tub, in order to prevent the dispersion of the gas. The cloth is wound, or the frame-work on which the skeins are suspended is turned several times, until it is judged, by taking out a small quantity of the liquor from time to time, and trying it by the test of the solution of Indigo, that it is sufficiently exhausted. The weakened liquor is then drawn off, and may be again employed for a new saturation.

Observations. Great difficulties for a time impeded the progress of this method of bleaching, arising chiefly from prejudice, and the ignorance of bleachers in chemical processes. These obstacles were, however, removed by Mr. Watt, of Glasgow, and Mr. Henry, and Mr. Cooper, at Manchester. Another difficulty presented itself, which had nearly proved fatal to the success of the operation. This was the want of a proper apparatus, not for making the acid and combining it with water, for this had been supplied in a very ingenious manner by Mr. Watt, and M. Berthollet; but for the purpose of immersing and bleaching goods in the liquor. The volatility of this acid, and its suffocating vapours, prevented its application in the way commonly used in dye-houses. Large cisterns were therefore constructed, in which pieces of stuff were stratified: and the liquor being poured on them, the cisterns were closed with lids. But this method was soon found to be defective, as the liquor could not be equally diffused; the pieces were therefore only partially bleached, being white in some parts, and more or less coloured in others.

Mr. Rupp, of Manchester, invented an apparatus for bleaching cloth, exceedingly simple in its construction, of small expence, and which contains the liquor in such a manner as to prevent the escape of the oxygenated muriatic acid gas. A consideration of no less importance in the arrangement of this apparatus, is the impossibility of the vapour injuring the health of the workmen.

It was found, however, that the use of the oxygenated muriatic acid, alone, weakened the cloth, and various methods for preventing its noxious effects upon the health of the workmen were tried without success; till it was discovered that an addition of alkali to the liquor, deprived it of its suffocating effects, without destroying its bleaching powers. The process began then to be carried on in open vessels, and has been continued in this manner to the present period. The bleacher is now able to work his pieces in the liquor, and to expose every part of them to its action, without inconvenience.

Potash was at first used for this purpose; and although this advantage was unquestionably great, it was diminished by the heavy expence of the potash, which was entirely lost. Also, the potash which was added to the liquor, though it did not destroy its power of bleaching, diminished it; because a solution of the oxygenated muriate of potass, which differs from this bleaching liquor in nothing but in the proportion of alkali, will not bleach at all. This is a well-known fact, from which we might infer, that the oxygenated muriatic acid will lose its power of destroying the colouring matter of vegetable substances, in proportion as it becomes neutralized by potass.

It was afterwards discovered that the oxy-muriatic acid might be combined with the alkaline earths, as lime and barytes, and also with magnesia; by this means forming oxy-muriates, which were soluble in water, and had the property of bleaching. The oxy-muriate of lime is at present, used in almost all the bleaching-grounds.

DCCCLXIX.

Bleaching by means of the Oxy-Muriate of Lime.

If the Oygenated Muriatic Acid is passed through Lime-water, it will combine with the Lime, and form Oxy-muriate of Lime; but as the water can only retain a small portion of Lime, this was not found of much use. To cause a larger quantity of Lime to combine with the Oxy-muriatic Acid Gas the Lime is mechanically suspended in the water, into which the gas is made to pass, and agitated, so as to present fresh matter to the gas. By this means, the Oxy-muriate of Lime is formed in a very convenient manner; it is dissolved in water, and used as a bleaching liquor.

This liquor is found to be preferable to the oxygenated muriatic Acid, and potass. At the great bleach-field in Ireland, four leys of potash are applied alternately with four weeks exposure on the grass, two immersions in the Oxygenated muriate of Lime, a ley of potash between the two, and the exposure of a week on the grass between each ley, and the immersions. During summer, two leys and fifteen days exposure are sufficient to prepare cloth for the action of the Oxygenated muriate; the three alternate leys, with immersions in the liquor, will be sufficient to complete the bleaching: nothing then will be necessary, but to wind the cloth through the Sulphuric Acid.

Observations. The oxygenated muriatic acid gas may also be combined with lime in a dry state, or the water may be evaporated, when it is employed for the formation of oxy-muriates, which may then be very conveniently transported to any distance without injury to its detersive power.

DCCCLXX.

To Bleach by means of the Sulphuret of Lime.

To find a detersive substance, which might be a substitute for Potass, was an object of the utmost importance. Mr. Kirwan suspected that it would be found in the Sulphuret of Lime, and his opinion was confirmed, by Dr. Higgins. Sulphur and Lime are both cheap articles; they are very easily combined and this combination completely answers the purposes of Potass, without any danger of injuring the linen.

The Sulphuret of Lime is prepared in the following manner for the purpose of bleaching: Sulphur or brimstone, in fine powder, four pounds; Lime, well slacked and sifted, twenty pounds; water, sixteen gallons; these are to be well mixed, and boiled for about half an hour in an iron vessel, stirring them briskly from time to time. Soon after the agitation of boiling is over, the solution of the Sulphuret of lime clears, and may be drawn off free from the insoluble matter, which is considerable, and which rests upon the bottom of the boiler. The liquor, in this state, is pretty nearly of the colour of small beer, but not quite so transparent.

Sixteen gallons of fresh water are afterwards to be poured upon the insoluble dregs in the boiler, in order to separate the whole of the Sulphuret from them. When this clears (being previously well agitated), it is also to be drawn off and mixed with the first liquor; to these, again, thirty-three gallons more of water may be added, which will reduce the liquor to a proper standard for steeping the cloth. Here we have (an allowance being made for evaporation, and for the quantity retained in the dregs) sixty gallons of liquor from four pounds of brimstone.

Although Sulphur, by itself, is not in any sensible degree soluble in water, and Lime but sparingly so, water dissolving only about one seven-hundredth part of its weight of Lime, yet the Sulphuret of Lime is highly soluble.

When linen is freed from the weaver's dressing, in the manner already described, it is to be steeped in the solution of Sulphuret of Lime (prepared as above) for about twelve or eighteen hours, then taken out and very well washed. When dry, it is to be steeped in the Oxymuriate of Lime for twelve or fourteen hours, and then washed and dried. This process is to be repeated six times, that is, by six alternate immersions in each liquor, which has been found to whiten the linen.

Observation. Steam has been lately employed for bleaching with great success in France. The process was brought from the Levant. Chaptal first made it known to the public.

DCCCLXXI.

BLEACHING BY MEANS OF ALKALISED STEAM.

In the process of bleaching by Steam, the high temperature swells up the fibres of the thread or cloth; the pure alkali, which rises with the elastic fluid, seizes with avidity on the colouring matter; and seldom does the tissue of the flax, or hemp, resist the penetrating effect of this vapour-bath. The whole matter, therefore, by which they are coloured, is attacked and decomposed by this single operation; and even if we suppose that a part has been able to resist, nothing is necessary but to repeat the operation, after a previous immersion and exposure on the grass, to ensure its complete effect. The alkali even appears to have a much livelier and more caustic action, when it is combined with caloric, than in ordinary leys, where the temperature never rises above 162° of Fahrenheit. By making the cloth, or thread, pass through one ley of Oxygenated Muriate of Lime, an union is effected between the solution and the carbon, arising from the extracto-mucous matter of the flax; Carbonic Acid is formed; the water, even, in which this new compound is diluted, concurs to promote the combination; if the cloth is then exposed on the grass, the Carbonic Acid is dissipated, and the cloth is bleached.

It was believed that the steam of a pure alkaline ley would not be caustic, and would not produce the same effect as the saline solution; and the reason assigned for this opinion was the concentration of all the salts by the evaporation of the aqueous fluid: but what takes place in the open air, where the atmosphere every moment absorbs the moisture which is evaporated, cannot be applied to a close apparatus, where the temperature is elevated in an extreme degree; besides, the caloric always carries with it a little alkali, even in low temperatures, as is observed when hot water is Poured over potass; the steam which issues from it changes blue vegetable colours to green.

It follows, from these principles, that the action of steam alone does not bleach, and that the concurrence of Oxygen is necessary to aid the composition of the Carbonic Acid; this acid requires for its formation, 28 parts of Carbon, saturated with 72 of Oxygen: but all the Oxygen contained in the apparatus would not be sufficient to saturate the considerable quantity of colouring matter burnt by the alkaline combustion, and converted into Carbon; this deficit must be supplied by immersion in any Oxygenated liquor whatever, and the dispersion of the elastic fluid thus formed must be then facilitated by exposure on the grass.

To bleach cloth in this manner, it must be immersed in a slight alkaline caustic liquor, and placed in a chamber constructed over a boiler, into which is put the alkaline ley which is to be raised into Steam. After the fire has been lighted, and the cloth has remained exposed to the action of the steam for a sufficient length of time, it is taken out, and immersed in the Oxygenated Muriate of Lime, and afterwards exposed for two or three days on the grass. This operation, which is very expeditious, will be sufficient for cotton; but if linen cloth should still retain a yellow tint, a second alkaline caustic vapour-bath, and two or three days on the grass, will be sufficient to give it the necessary degree of whiteness.

BLEACHING OF COTTON.

Cotton is a filamentous substance, or a kind of down which envelopes the seeds of the cotton-plant. This plant, or shrub, comes originally from the East, and grows only in warm climates.

This substance, after being separated from the seeds, is always charged with a coarse colouring matter, which soils it, and renders it opaque. The presence of this unctuous matter is proved by the slowness with which cotton absorbs water before it is scoured, and by the force with which it absorbs it after the operation; by which means, from being opaque, it is rendered clear and transparent.

Cotton varies a great deal in its qualities, according to the different kinds, the climate where produced, and the culture employed. Its colour is sometimes yellow, and sometimes white; but in general it is of a dirty yellow.

DCCCLXXII.

To Bleach Cotton

To bleach it, does not require the same preparations as hemp and flax. The first operation consists in scouring it in a slight alkaline solution; or, what is better, by exposure to Steam. It is afterwards put into a basket, and rinsed in running water. The immersion of cotton in an alkaline ley, however it may be rinsed, always leaves with it an earthy deposit. It is well known that cotton bears the action of acids better than hemp or flax; that time is even necessary before the action of them can be prejudicial to it; and by taking advantage of this valuable property in regard to bleaching, means have been found to free it from the earthy deposit, by pressing down the cotton in a very weak solution of Sulphuric Acid, and afterwards removing the acid by washing, lest too long remaining in it should destroy the cotton.

Bleaching of Wool.

The substances produced by the animal kingdom differ essentially in their constituent principles from vegetables. Vegetables serve as the nourishment to the animals and the insects, the spoils of which we employ. Animalized by their organs, they acquire other properties.

Wool is a finer kind of hair with which the bodies of several animals are covered. It is composed of filaments or tubes, filled with an oily, or medullary, substance. The sides of these tubes are perforated with a multitude of small pores, which communicate with a longitudinal tube. By chemical analysis, wool gives a great deal of oil, and carbonate of ammonia; caustic alkaline leys dissolve it entirely. It experiences no change in boiling-water; it alters very little when preserved in a place well aired; acids have very little action on it; when exposed to a strong heat, it enters into fusion.

An examination of these chemical facts is necessary for understanding the principles which ought to direct the artist in the bleaching of this substance. The little action which acids have upon wool, and its unalterableness in water, even when aided by heat, render it necessary to have recourse to alkaline or saponaceous leys; but its solubility in these salts shews, that great prudence and caution must be employed. In regard to acids, none have been hitherto used but the sulphurous acid, obtained in the gaseous state by combustion.

DCCCLXXIII.

METHODS TO BE ADOPTED FOR BLEACHING WOOL.

In the preliminary operations to which Wool is subjected, it is customary to leave a little of its grease, to secure it from insects. Wool is often freed from the grease by the farmers, when they wish to sell it at a high price; but in the subsequent manipulations, it is greased or oiled before it is combed, spun, &c.: and as this fat matter attracts dust, it dirties and thickens the stuffs. The first kind of bleaching to which wool is subjected, is to free it from these impurities. This operation is called scouring. In manufactories, it is generally performed by means of an ammoniacal ley, formed of five measures of river water and one of stale urine; the Wool is immersed for about twenty minutes in a bath of this mixture, heated to fifty-six degrees; it is then taken out, suffered to drain, and then rinsed in running water: this manipulation softens the Wool, and gives it the first degree of whiteness: it is repeated a second, and even a third time, after which the Wool is fit to be employed. In some places, scouring is performed with water slightly impregnated with soap; and indeed, for valuable articles, this process is preferable, but it is too expensive for articles of less value.

Fulling the cloth adds still to the whiteness; and if an increased degree is necessary, it may be procured by the action of the Sulphureous Acid; that is to say, of the fumes of Sulphur in a state of combustion, or the vapour of that acid condensed and combined with water.

Sulphuring is generally performed in an arched or very close chamber, constructed in such a manner, that the articles to be exposed to the action of the Sulphur can be suspended on poles. The chamber being filled, a certain quantity of Sulphur is put in a state of combustion in flat dishes, having a large surface with very little depth; the entrance is speedily shut, and all the interstices around the door are carefully stopped to prevent the access of the atmospheric air. The acid generated by the combustion of the Sulphur, penetrates the stuffs, attacks the colouring matter, destroys it, and effects the bleaching. The stuffs are left in the stoves some time after the combustion has ceased. This time varies from six to twenty-four hours. They are then taken out, and made to pass through a slight washing with soap, to remove the roughness they have acquired by the action of the acid, and to give them the necessary softness

This process is imperfect. At first, the acid of the Sulphur acts only on the surfaces, and does not penetrate. This aërial immersion is not sufficient; the gas cannot introduce itself to a sufficient depth into the stuffs, and the superficies only are whitened.

A superior method has been lately invented, which is by making use of the Sulphurous Acid.

The Sulphurous Acid, or that acid generated by the imperfect combustion of Sulphur, differs from the Sulphuric Acid (oil of vitriol), by its containing less of the acidifying principle.

Sulphurous Acid gas unites very easily with water, and in this combination it may be employed for bleaching Wool and Silk. The Sulphurous Acid, in this state of liquidity, may be prepared by making it traverse water in an apparatus nearly similar to that used for preparing Oxygenated Muriatic Acid. The most economical method of obtaining it, is to decompose Sulphuric Acid, by the mixture of any combustible matter capable of taking from it a part of its Oxygen. In exact experiments of the laboratory, when the chemist is desirous of having it in great purity, it is obtained by means of metallic substances, and particularly by Mercury; but for the purpose of which we are treating, where great economy is required, we should recommend the most common substances. Take chopped straw, or saw-dust, and introduce it into a Mattrass; pour over it Sulphuric Acid, applying at the same time heat, and there will be disengaged Sulphurous Acid gas, which may be combined with water in the apparatus.

The pieces are rolled upon the reels, and are drawn through the Sulphurous Acid by turning them, until it is observed that the whiteness is sufficiently bright. They are then taken out, and are left to drain on a bench covered with cloth, lest they should be stained in consequence of the decomposition of the wood by the Sulphurous Acid; they are next washed in river water, and Spanish-white is employed, if it should be judged necessary. This operation is performed by passing the pieces through a tub of clear water, in which about eight pounds of Spanish-white have been dissolved. To obtain a fine whiteness, the stuffs, in general, are twice sulphured. According to this process, one immersion, and reeling two or three hours, are sufficient. Azuring, or bluing, is performed by throwing into the Spanish-white liquor a solution of one part of Prussian blue to 400 parts of water; shaking the cloth in the liquid, and reeling it rapidly. The operation is terminated by a slight washing with soap, to give softness and pliability to the stuffs.

FULLING.

Fulling is the art of cleansing, scouring, and pressing cloths, stuffs, and stockings, to render them stronger, closer, and firmer; called also milling. The fulling of cloths and other stuffs is performed by a kind of water-mill, thence called a fulling, or scouring, mill. These mills, except in what relates to the mill-stones and hopper, are much the same with corn-mills: and there are even some which serve indifferently for either use; corn being ground, and cloths fulled, by the motion of the same wheel. Whence in some places, particularly in France, the fullers are called millers; as grinding corn, and milling stuffs, at the same time.

The principal parts of the fulling-mill are:-the wheel, with its trundle; which gives motion to the tree or middle, whose teeth communicate with the pestles or stampers, which are hereby raised and made to fall alternately, according as its teeth catch on, or quit a kind of latch in the middle of each pestle. The pestles and troughs are of wood; each trough having at least two, sometimes three, pestles, at the discretion of the master, or according to the force of the stream of water. In these troughs are laid the cloths, stuffs, &c. intended to be fulled: then, letting the current of water fall on the wheel, the pestles are successively let fall thereon, and by their weight and velocity, stamp and press the stuffs very strongly, which by these means become thickened and condensed. In the course of the operation, they sometimes make use of urine, sometimes of fuller's earth, and sometimes of soap. To prepare the stuffs to receive the first impressions of the pestle, they are usually laid in urine; then in fuller's earth and water; and, lastly, in soap dissolved in hot water. Soap alone would do very well; but this is expensive: though fuller's earth, in the way of our dressing, is scarcely inferior to it; but then it must be well cleared of all stones and grittinesses, which are apt to make holes in the stuff. As to urine, it is certainly prejudicial, but ought to be entirely discarded; not so much on acoount of its ill smell, as of its sharpness and saltness, which qualities are apt to render the stuffs dry and harsh.

DCCCLXXIV.

ART OF FULLING CLOTHS, WOOLLENS, &c.

The method of Fulling cloths and woollen stuffs with soap, is this. a coloured cloth, of about 45 ells, is to be laid in the usual manner in the trough of a fulling-mill, without first soaking it in water, as is commonly practised in many places. To full this trough of cloth, 15 pounds of soap are required, one-half of which is to be melted in two pails of river, or spring water, made as hot as the hand can well bear it. This solution is to be poured by little and little upon the cloth, in proportion as it is laid in the trough; and thus it is to be fulled for at least two hours; after which it is to be taken out and stretched. This done, the cloth is immediately returned into the same trough, without any new soap, and there fulled two hours more. Then taking it out, they wring it well, to express all the grease and filth. After the second fulling, the remainder of the soap is dissolved as in the former, and cast four different times on the cloth, remembering to take out the cloth every two hours to stretch it, and undo the plaits and wrinkles it has acquired in the trough. When sufficiently fulled, and brought to the quality and thickness required, scour it in hot water, keeping it in the trough till it is quite clean. As to white cloths, as these full more easily, and in less time than coloured ones, a third part of the soap may be spared.

Observations. The fulling of stockings, caps, &c. should be performed somewhat differently, viz. either by the feet or the hands, or by a kind of wooden rack, either armed with teeth of the same matter, or else horses, or bullocks teeth. The ingredients made use of are, urine, green soap, white soap, and fuller's earth. But the urine also is reckoned prejudicial here. Woven stockings, &c. should be fulled with the soap alone: for those that are knit, earth may be used with the soap. Indeed it is common to full these kinds of works by the mill, after the usual manner of cloth, &c.; but that is too coarse and violent a manner, and apt to damage the work, unless it is very strong.

BLEACHING OF SILK.

Silk is a semi-transparent matter, spun by a caterpillar, and formed of a substance contained in its body, which becomes hard in the air. This insect inhabits warm climates, being indigenous in Asia: it was naturalized in Europe about the time of the downfall of the Roman Empire.

The filaments prepared by the silkworm are rolled up in a pod or ball. In this state, in which we find it, it is covered with a yellow varnish, which destroys its brilliancy and renders it rough. Silk by chemical analysis gives carbonate of ammonia and oil; water at a boiling heat produces no effect upon it; alcohol makes it experience no change; but concentrated alkaline leys attack and dissolve it.

To give splendour to silk, it must be freed from its varnish. This covering is soluble in alkaline leys. Silk is generally scoured by means of soap, by which it loses one-fourth of its weight. The matter disengaged from it is very fetid, and if the silk is not rinsed in plenty of water, putrid fermentation will take place. Even when the best soap is used, it is generally suspected that it injures the whiteness of the silk. The splendour of the Chinese silk is brighter than that of the European, and the Chinese employ no soap in their operations. A slightly alkaline ley will dissolve the varnish of the silk without using soap, and this has also been effected by the action of boiling water at a very high temperature.

DCCCLXXV.

METHOD OF BLEACHING SILK.

The method which has been used successfully in France is as follows:

Take a solution of caustic Soda, so weak as to mark only a fourth of a degree, at most, of the areometer for salts, and fill with it the boiler of the apparatus for bleaching with steam. Charge the frames with skeins of raw silk, and place them in the apparatus until it is full; then close the door, and make the solution boil. Having continued the ebullition for twelve hours slacken the fire, and open the door of the apparatus. The heat of the Steam, which is always above 250°, will have been sufficient to free the silk from the gum, and to scour it. Wash the skeins in warm water; and, having wrung them, place them again on the frames in the apparatus, to undergo a second boiling. Then wash them several times in water, and immerse them in water somewhat soapy, to give them a little softness.

Notwithstanding the whiteness which silk acquires by these different operations, it must be carried to a higher degree of splendour by exposing it to the action of Sulphurous Acid Gas, in a close chamber, or by immersing it in Sulphurous Acid, as before recommended for Wool.

DCCCLXXVI.

TO BLEACH PRINTS, AND PRINTED BOOKS.

An application has been made of this mode of bleaching, to the whitening of books and prints, that have been soiled by smoke and time.

Simple immersion in Oxygenated Muriatic Acid, letting the article remain in it, a longer, or shorter space of time, according to the strength of the liquor, will be sufficient to whiten an engraving: if it is required to whiten the paper of a bound book, as it is necessary that all the leaves should be moistened by the acid, care must be taken to open the book well, and to make the boards rest on the edge of the vessel, in such a manner that the paper alone shall be dipped in the liquid; the leaves must be separated from each other, in order that they may be equally moistened on both sides.

The liquor assumes a yellow tint, and the paper becomes white in the same proportion; at the end of two or three hours, the book may be taken from the acid liquor, and plunged into pure water, with the same care and precaution as recommended in regard to the acid liquor, that the water may exactly touch the two surfaces of each leaf. The water must be renewed every hour, to extract the acid remaining in the paper, and to dissipate the disagreeable smell.

Observations. By following this process, there is some danger that the pages will not be all equally whitened; either because the leaves have not been sufficiently separated, or because the liquid has had more action on the front margins than on those near the binding. On this account, the best way is to destroy the binding entirely, that each leaf may receive an equal and perfect immersion. This is the process recommended by M. Chaptal.

"They begin," says he, "by unsewing the book, and separating it into leaves, which they place in cases formed in a leaden tub, with very thin slips of wood or glass; so that the leaves, when laid flat, are separated from each other by intervals scarcely sensible. The acid is then poured in, making it fall on the sides of the tub, in order that the leaves may not be deranged by its motion. When the workman judges, by the whiteness of the paper, that it has been sufficiently acted upon by the acid, it is drawn off by a cock at the bottom of the tub, and its place is supplied by clear fresh water, which weakens and carries off the remains of the acid, as well as the strong smell. The leaves are then to be dried, and after being pressed, may be again bound up.

"The leaves may be placed also vertically in the tub; and this position seems to possess some advantage, as they will be less liable to be torn. With this view I constructed a wooden frame, which I adjusted to the proper height, according to the size of the leaves which I wished to whiten. This frame supported very thin slips of wood, leaving only the space of half a line between them. I placed two leaves in each of these intervals, and kept them fixed in their place by two small wooden wedges, which I pushed in between the slips. When the paper was whitened, I lifted up the frame with leaves, and plunged them in cold water, to remove the remains of the acid, as well as the smell; this process I prefer to the other.

"By this operation books are not only cleaned, but the paper acquires a degree of whiteness superior to what it possessed when first made. The use of this acid is attended also with the valuable advantage of destroying ink-spots. This liquor has no action upon spots of oil or animal grease; but it has been long known that a weak solution of potass will effectually remove stains of that kind.

"When I had to repair prints so torn that they exhibited only scraps pasted upon other paper, I was afraid of losing these fragments in the liquid, because the paste became dissolved. In such cases, I inclosed the prints in a cylindric glass vessel, which I inverted on the water in which I had put the mixture proper for extricating the oxygenated muriatic acid gas. This vapour, by filling the whole inside of the jar, acted upon the print, extracted the grease as well as ink-spots, and the fragments remained pasted to the paper."

To oxygenate common muriatic acid, dilute it, and mix it, in a very strong glass vessel, with manganese; in such a manner that the mixture may not occupy the whole contents of the glass. Air-bubbles are formed on the surface of the liquor; the empty space becomes filled with a greenish vapour; and at the end of some hours the acid may be farther diluted with water, and then used. It has an acid taste, because the whole is not saturated with oxygen; but it possesses all the virtues of the oxygenated muriatic acid. This process may be followed when there is not time to set up an apparatus for distilling, in order to procure the oxygenated acid.

DCCCLXXVII.

To REMOVE THE STAINS OF INK.

The stains of ink, on cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred, which are least likely to injure the texture of the stained substance. The Muriatic Acid, diluted with five or six times its weight of water, may be applied to the spot, and, after a minute or two, may be washed off, repeating the application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the Oxalic, Citric (acid of lemons), or Tartareous acids, in water, may be applied to the most delicate fabrics without any danger of injuring them: and the same solutions will discharge writing, but not printing-ink. Hence they may be employed in cleaning books which have been defaced by writing on the margin, without impairing the text. Lemon-juice, and the juice of sorrel, will also remove ink-stains, but not so easily as the concrete acid of lemons, or Citric acid.

DCCCLXXVIII.

PROCESS FOR THE RE-FABRICATION OF THE PRINTED *Paper of Old Books.*

All Paper of the same quality should be collected, and separated from such as may have any writing on the pages; the edges of those leaves which may have become yellow, and also the backs of books, being cut off by the instrument used by book-binders. One hundred weight of paper is now to be put, sheet by sheet, into a vat, sufficiently capacious to contain it, together with 500 quarts of hot water. The whole is next stirred by two men for the space of one hour, who are gradually to add as much water as will rise about three inches above the paper; after which it is left to macerate four or five hours; the agitation being occasionally repeated, so as to separate, and at length to form the paper into a kind of paste

The water is now to be drawn off by means of pipes, and the pulp conveyed to the mill, where it is to be coarsely ground for one hour; at the expiration of which it is boiled in a cauldron for a similar space, with a sufficient quantity of water to rise four or five inches above it. A short time before the mixture begins to boil, thirteen quarts of ley of caustic potass, are to be added to every cwt. of paper. The ley alluded to is prepared by dissolving 100 lbs. of carbonate of potass, in 300 quarts of boiling water, to which are to be added 20 lbs. of pulverized quick-lime; and the whole must be briskly agitated, till it becomes of an uniform consistence, when it is suffered to stand for 12 hours. At the end of this time it must be drawn off, and 75 quarts of boiling water added to the sediment, which being stirred for half an hour, and suffered to stand till it become clear, is to be mixed with the liquor first decanted.

When the paste has boiled in this ley for one hour, the fire is to be extinguished, and the matter suffered to macerate for 12 hours; after which it must be taken out, drained, put into bags, and submitted to the action of a strong press for a similar length of time, to deprive it of all moisture; and, if it appear white, so that the printer's ink be properly extracted, it may be re-manufactured in the usual manner.

DCCCLXXIX.

PROCESS FOR THE RE-FABRICATION OF PAPER *After being written upon.*

The Paper must be sorted; the yellow edges cut off; and the whole thrown, leaf by leaf, into a tub half full of boiling water, where it is to be agitated as in the foregoing process. After it has macerated four hours, the water should be drawn off; a fresh quantity of boiling water added; and the mixture stirred for half an hour: at the expiration, of which, the paper is again left to dissolve for three hours.

The fluid is now drawn off, and 260 quarts of cold water are to be poured on each cwt. of paper; which being perfectly mixed, 6 lbs. of sulphuric acid are to be gradually added; and the whole is to be strongly agitated for a considerable time, that the paper may thoroughly imbibe the liquor.

This composition is next suffered to macerate for twelve hours; the agitation being occasionally repeated, when the tub is to be filled up with cold water; and the mixture again stirred, to wash the paper, which will now be reduced to a perfect paste. Lastly, after drawing off the water, the pulp must be put into bags, pressed, and ground in a mill; after which it is conveyed to the vat, and worked in the manner practised with linen rags.

Observation. In the year 1801, a patent was granted for extracting ink from printed paper, and restoring it to its original state.

The process varies little from those above described; the paper being agitated in hot water to extract the size, and to reduce it into a pulp: the adhesion of the ink is to be removed by a caustic alkali prepared of lime and potass, the quantities of which should be proportioned to those of the paper. After discharging the ink, the pulp is to be bleached by means of the oxygenated muriatic acid, in the proportion of 10 or 12 gallons to 140 lbs of the material; and when sufficiently whitened, it is to be re-manufactured in the usual manner. According to the patentee's account, writing paper does not require so large a proportion, if any, of the caustic alkali; but is bleached by confining it in a wooden box, rendered air-tight, into which the acid gas is thrown directly from the retort wherein it is produced.

When writing with common ink has been effaced by means of oxygenized muriatic acid, the vapour of sulphuret of ammonia, or immersion in water impregnated with the sulphuret, will render it again legible. Or if the paper that contained the writing be put into a weak solution of prussiate of potass, and when it is thoroughly wet, sulphuric acid be added to the liquor, so as to render it slightly acidulous, the same purpose will be answered.

DCCCLXXX.

PARTIAL DEOXIDATION OF SULPHATE OF INDIGO BY *Muriate of Tin.*

Into a solution of Indigo in Sulphuric Acid, pour some newly made solution of Tin in Muriatic Acid. The intensely blue colour will be instantly changed to a beautiful green; this is caused by abstraction of the Oxygen of the Indigo.

DCCCLXXXI.

COMPLETE DEOXIDATION OF SULPHATE OF INDIGO BY *Chlorine.*

Into a solution of Indigo in Sulphuric Acid, pour some liquid Chlorine; the blue colour will be completely destroyed, and the solution rendered *colourless.*

DCCCLXXXII.

PREPARATION OF THE FAMOUS CHEMICAL LIQUID

For cleansing Boot-tops, &c.

Mix in a phial, one dram of Oxy-Muriate of Potass with two ounces of distilled water; and, when the salt is dissolved, add two ounces of Muriatic Acid. Then, shaking well together, in another phial, three ounces of rectified spirit of wine with half an ounce of the essential oil of lemon, unite the contents of the two phials, and keep the liquid, thus prepared, closely corked for use. This chemical liquid should be applied with a clean sponge, and dried in a gentle heat; after which, the boot tops may be polished with a proper brush, so as to appear like new leather.

Observations. Many of the liquids sold under various denominations, for the purpose of cleaning and restoring the colour of boot-tops, &c. are found very imperfectly to answer that purpose, and often to injure the leather. The foregoing genuine receipt may be fully relied on, for actually producing this desirable effect; as well as for readily taking out ink spots, and the stains occasioned by the juice of fruits, port wine, &c. from leather ,or parchment.

DCCCLXXXIII.

METHOD OF CLEANSING FEATHERS FROM ANIMAL OIL.

Take, for every gallon of clear Water, a pound of quick Lime; mix them well together; and, when undissolved Lime is precipitated in fine powder, pour off the clear Lime-water for use, *at the time it is wanted.* Put the feathers to be cleaned in a tub, and add to them a sufficient quantity of the clear Lime-water so as to cover them about three inches. The feathers, when thorougly moistened, will sink down, and should remain in the Lime-water for three or four days; after which, the foul liquor should be separated from them by laying them on a sieve. They should be afterwards well washed in clean Water, and dried on nets, the meshes being about the same fineness as those of cabbage nets. They must, from time to time, be shaken on the nets; as they dry, they will fall through the meshes, and are to be collected for use. The admission of air will be serviceable in the drying, and the whole process may be completed in about three weeks. The feathers, after being thus prepared want nothing further than beating, to be used either for beds, bolsters, pillows, or cushions.

DCCCLXXXIV.

White Colours in Paintings restored

By Oxygenated Water.

A French painter, of the name of Merimée, having observed, in a design by Raphael, that the lights had lost their brightness, applied to M. Thenard for his advice. This chemist ascribed the effect to the circumstance, that the White Lead dissolved in Water had become Sulphuretted by the lapse of time, and had been changed from white to black. Accordingly, he sent to M. Merimée some slightly Oxygenated Water, which was applied to the black parts, and the white colour was instantly restored. The Water contained only five or six times its volume of Oxygen.

DCCCLXXXV.

To restore the Lustre of Gold, or Silver Lace,

When Tarnished.

When Gold, or Silver lace happens to be tarnished, the best liquor that can be used for restoring its lustre, is spirits of wine; it should be warmed before it is applied to the tarnished spot. This application will preserve the colour of the silk, or embroidery.

DCCCLXXXVI.

Whitening Silver by Boiling.

Whitening silver by boiling is one of the methods of parting copper from silver in the humid way. For this purpose, silver wrought in any shape is first ignited to redness, and afterwards boiled in a ley of Muriate of Soda, and Acidulous Tartrite of Potass. By these means the Copper is removed from the Surface, and the Silver receives a better appearance.

DCCCLXXXVII.

Method of Cleaning Silks, Woollens, and Cottons,

Without Damage to their Texture and Colour.

Grate raw Potatoes to a fine pulp in clean Water, and pass the liquid matter, through a coarse sieve, into another vessel of Water: let the mixture stand still till the fine white particles of the Potatoes are precipitated; then pour the mucilaginous liquor from the fecula, and preserve the liquor for use. The article to be cleaned should then be laid upon a linen cloth on a table, and having provided a clean sponge, dip it into the Potatoe liquor, and apply it to the article to be cleaned, till the dirt is perfectly separated; then wash it in clean Water several times. Two middle-sized Potatoes will be sufficient for a pint of Water.

Observations. The coarse pulp, which does not pass through the sieve, is of great use in cleaning worsted curtains, tapestry, carpets, and other coarse goods. The mucilaginous liquor will clean all sorts of silk, cotton, or woollen goods, without hurting or spoiling the colour; it may be also used in cleaning oil paintings, or furniture that is soiled. Dirtied painted wainscots may be cleaned by wetting a sponge in the liquor; then dipping it in a little fine clean sand, and afterwards rubbing the wainscot with it.

DCCCLXXXVIII.

Scouring Balls.

Portable Balls for removing spots from clothes, may be thus prepared. Fuller's earth perfectly dried, so that it crumbles into a powder; it is to be moistened with the clear juice of lemons, and a small quantity of pure pearl-ashes is to be added. Knead the whole carefully together, till it acquires the consistence of a thick elastic paste: form it into convenient small balls, and dry them in the sun. To be used, first moisten the spot on the clothes with water, then rub it with the ball, and let the spot dry in the sun; after having washed it with pure water, the spot will entirely disappear.

CHAPTER XIX.

FERMENTATION AND DISTILLATION.

General Observations.

THE arts of fermentation and distillation have been practised from the most remote antiquity; they consist, in the first place, in the preparation of a vinous, or spirituous liquid, from farinaceous substances capable of being converted into Saccharine matter, or Sugar: and in the second, in separating the spirituous from the watery particles of the fermented liquor. Porter, Ale, Beer, and Wine, are products of the former mode of operation: whilst Rum, Brandy, Whisky, and Arrack are those of the latter. The existence of the latter, (which are all modifications of one substance, Alcohol,) in the former, is the cause of that intoxicating, or exhilerating quality which is so peculiar to fermented liquors. The substances commonly in use, for the preparation of these liquors, are Sugar, Grapes and Barley; although there are various other substances used for the same purpose in many parts of the world.* The species of fermentation in question is generally denominated Vinous; but there are two other kinds, viz.; the *Acetous*, and the *Panary*, which, being those which take place in the preparation of Vinegar, and Wheaten Bread, shall be considered in order.

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* The *sake* of the Chinese is prepared with *rice*; (the saccharine ingredient, or that which, by fermentation, is productive of the alcohol;) the *chica* of the North-Americans with *maize*: the *quass* of the Russians with a composition of barley, rye, and oats: the *koumiss* of the Tartars is composed of fermented mare's milk, and some aromatic substances, as angelica, or the heracleum. The Swedes make a sort of beer of various fruits and grains, fermented together, as juniper-berries, plumbs, mulberries, cherries, gooseberries, &c. The art of making beer appears to have originated in Egypt, and to have extended thence

BREWING, OR THE PREPARATION OF FERMENTED LIQUORS.

Barley, which consists of fecula or starch, albumen and gluten, is the substance commonly employed for brewing ale, porter, and beer in this country ; but before these several liquors can be properly prepared, it is necessary that the ingredients should undergo some previous operations.

MALTING, or the conversion of barley into malt, is the first process in the making of beer. The grain is put into a trough with water, to steep for about three days : it is then laid in heaps, to let the water drain from it, and it is afterwards turned over and laid in new heaps. In this state, the same process takes place, as if the barley were sown in the ground. It begins to germinate, puts forth a shoot, and the fecula of the seed is converted into saccharine matter. When the length of the shoot is about ⅔ of the length of the grain, this process of germination must be stopped, otherwise the sugar would be lost, nature intending it for the nourishment of the young plant. The malt is therefore spread out upon a floor, and frequently turned over: this cools it, and dries up its moisture, without which the germination cannot proceed. When it is completely dried, in this manner, it is called *air-dried* malt, and is very little altered in colour. But when it is dried in kilns, it acquires a brownish colour, which is deeper in proportion to the heat applied ; it is then called *kiln-dried.* This malt is now coarsely ground in a mill.

MASHING is the next process. This is performed in a large circular wooden vessel, called the mash tun, shallow in proportion to its extent, and furnished with a false bottom, pierced with small holes, and fixed a few inches above the real bottom. There are two side openings, in the

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along the coast of Asia, to the northern parts of that quarter of the globe ; and hence, to the corresponding part of Europe, with the Scythians.

Beer is not now used in Egypt, nor on the greater part of the coasts of the Mediterranean, (though Mungo Park says the negroes prepare it, and in a way nearly similar to that generally adopted in Europe,) but it has, to the present time, continued a favourite drink with the northern nations of Europe. This liquor very readily produces intoxication, and these people have preserved enough of the disposition of their ancestors,—to whom ODIN promised drunkenness as one of the joys of his paradise,—to like it on this account. Distillation from fermented substances produces liquors commonly called *spirits,* as a general appellative ; various kinds of which are prepared by different nations ; thus *brandy* is obtained from grapes, *rum* from the juice of the sugar cane, *arrack* from rice, *whisky* from barley, oats, and several species of grain of the *cereal* kind, and this when flavoured by juniper berries, is called hollands, geneva, or gin ; treated thus by cherries, it is *kirschen-wasser.* Various compounds, as ratafie, noyau, rosolio, &c. are made by flavouring malt spirit with kernels, and other aromatics. Beers are also treated in a similar way, by adding *spruce,* (the resinous juice of various species of *pines,*) and formerly, they were much in use as medicines, amongst the lower classes of people in England, when various drugs and vegetables, as gentian, senna, aloes, rhubarb, horse-radish, scurvy-grass, wild-carrot seeds, &c. had been macerated in them. The substances from which wine, cyder, perry, and mead, are prepared, are too well known to require being here designated.

interval between the real and false bottom: to one is fixed a pipe, for the purpose of conveying water into the tun: the other is for drawing the liquor out of it. The malt is to be strewed over the false bottom of the tun, and then, by means of the side pipe, a proper quantity of hot water is introduced from a copper. The water rises upwards through the malt, and when the whole quantity is introduced, the mashing begins; the object of which is, that the soluble parts may be extracted by it. For this purpose, the grist is sometimes incorporated with the water by iron rakes, and then the mass is beaten and agitated by long flat wooden poles, resembling oars, which are either worked by the hand, or by machinery.

When the mashing is completed, the tun is covered, to prevent the escape of the heat, and the whole is suffered to remain still, in order that the insoluble parts may separate from the liquor: the side is then opened, and the clear wort allowed to run off, (slowly at first, but more rapidly as it becomes fine,) into the copper, or boiler placed below.

The chief thing to be attended to in mashing, is the temperature, which depends on the heat of the water, and the state of the malt. If the water is let in upon the grist *boiling hot*, the starch which it contains, will be dissolved, and converted into a gelatinous substance, in which all the other parts of the malt, and most of the water, would be entangled beyond the possibility of being recovered by any after process.

The most eligible temperature appears to be from 185° to 190° of Fahrenheit; for the first mashing, the heat of the water must be somewhat below this temperature, and *lower in proportion to the dark colour of the malt* made use of. For pale malt, the water may be 180°, but for brown it ought not to be more than 170°. The wort of the first mashing is always the richest in saccharine matter; but to exhaust the malt, a second and third mashing is required, in which the water may be safely raised to 190° or upwards.

The proportion of wort to be obtained from each bushel of malt depends entirely on the proposed strength of the liquor. It is said that 25 or 30 gallons of good table-beer may be taken from each bushel of malt. For ale and porter of the superior kinds, only the produce of the first mashing, or six or eight gallons, is to be used. Brewers make use of an instrument called a saccharometer, to ascertain the strength and goodness of the wort. This instrument is a kind of hydrometer, and shews the specific gravity of the wort, rather than the exact quantity of saccharine matter which it contains.

The next process is BOILING, and HOPPING. If only one kind of liquor is made, the produce of the three mashings is to be mixed together; but if ale and table-beer are required, the wort of the first, or first and second mashings, is appropriated to the ale, and the remainder is set aside for the beer.

All the wort destined for the same liquor, is transferred from the tun to the copper, and mixed with a certain proportion of hops. The better the wort, the more hops are required. In private families a pound of hops is generally used to every bushel of malt; but in public breweries, a much smaller proportion is deemed sufficient. When ale and table-beer are brewed from the same malt, the usual practice is to put the whole quantity of hops in the ale wort, which having been boiled some time, are to be transferred to the beer-wort, and with it to be again boiled.

The whole is now to be kept boiling as fast as possible, until, upon taking a little of the liquor out, it is found to be full of small flakes like those of curdled soap. The copper, in common breweries, is uncovered; but in those on a large scale, it is fitted with a steam-tight cover, from the centre of which passes a pipe, terminating by several branches in the mash tun. The steam, therefore, produced by the boiling, instead of being wasted, is let into the cold water, and thus raises it to the temperature required for mashing; besides impregnating it very sensibly with the essential oil of the hops.

When the liquor is boiled, it is to be discharged into a number of coolers, or shallow tubs, where it remains until it becomes sufficiently cool to be submitted to fermentation. The process of COOLING should be carried on as expeditiously as possible, particularly in hot weather. Liquor made from pale malt, and which is intended for immediate drinking, need not be cooled lower than 75 or 80 degrees; of course this kind of beer may be brewed in the hottest weather; but beer brewed from brown malt, and intended to be kept, must be cooled to 65° or 70° before it is fermented. Hence the Spring, and Autumn have been deemed the most favourable seasons for brewing the best malt liquor.

In the WORKING, the liquor gradually loses its transparency: an intestine motion, accompanied by a slight hissing noise, takes place throughout the whole contents of the vessel, and carbonic acid gas, is disengaged in the shape of small bubbles, which, when they arrive at the surface, burst. These bubbles are enveloped in thin films of glutinous matter, which, by constant accumulation, form the froth, scum, or barm, on the surface. This froth is usually called Yeast, and will cause fermentation in any other body of malt or saccharine liquor.

The last operations are TUNNING and BARRELLING. From the cooler the liquor is to be transferred into the *working* tun, and mixed with yeast, in the proportion of a gallon of yeast to four barrels of beer, in order to excite the vinous fermentation. In four or five hours the fermentation begins, and it requires from 18 to 48 hours, before the wort is fit to be put into the barrels. The fermented liquor may be fined by pouring into it a solution of isinglass, yolks of eggs, or gum-tragacanth; and it is then to be excluded from the air, by means of a tight bung.

DCCCLXXXIX.

PREPARATION OF LONDON PORTER.

A late writer has given to the world considerable information respecting the brewing of Porter. His intention being to exhibit the advantages derived from domestic brewing, he has annexed the price to each article of the composition. His list of ingredients in the following proportions, is that used in the first London Breweries.

	Average Expence. £.	s.	d.
One quarter of Malt	2	2	0
8 lbs. of Hops	0	12	0
6 lbs. of Treacle	0	2	0
Carried over.	£2	16	0

	Average Expence.		
	£.	*s.*	*d.*
Brought over	2	16	0
8 lbs. of Liquorice Root, bruised . .	0	8	0
8 lbs. of Essentia Bina	0	4	8
8 lbs. of Colouring	0	4	8
Capsicum, half an ounce	0	0	2
Spanish Liquorice, 2 ounces . . .	0	0	2
Cocculus Indicus, commonly called Cocculus India Berries, 1 ounce . . .	0	0	2
Salt of Tartar, 2 drams	0	0	1
Heading, ¼ of an ounce	0	0	1
Ginger, 3 ounces	0	0	3
Lime, 4 ounces, (when slacked: the Lime-water is to be poured into the Essentia Bina, or colour, in the making) . .	0	0	1
Linseed, 1 ounce	0	0	1
Cinnamon Bark, 2 drams	0	0	2
	3	14	7
Coals	0	3	0
Total Expence	£3	17	7

This will produce ninety gallons of good Porter, and fifty gallons of good Table Beer, the cost of the Porter, at the large Breweries, being 7*l.* 10*s.* and that of the Beer, 1*l.* 7*s.* leaving a profit, or saving, of 5*l.*

Observations. The *essentia bina* is composed of eight pounds of moist sugar, boiled in an iron vessel, (for no copper one could withstand the heat sufficiently,) till it becomes of a thick syrupy consistence, perfectly black, and extremely bitter.* The colouring is composed of eight pounds of moist sugar boiled till it attains a middle state, between bitter and sweet. It gives that fine mellow colour usually so much admired in good porter. These ingredients are added to the first wort, and boiled with it.

The *heading* is a mixture of half alum, and half copperas, ground to a fine powder. It is so called, from its giving to porter that beautiful head or froth, which constitutes one of the peculiar properties of porter, and which publicans are so anxious to raise to gratify their customers.

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* When making the essentia and colour, observe when it is boiled sufficiently. To make it liquid enough, to pour off into the liquor, add a little clear water, or lime water, to bring it to a proper temper; otherwise it will become a hard, dry, burnt substance.

The linseed, ginger, limewater, cinnamon, and several other small articles, may be added or withheld according to the taste, custom, or practice of the brewer, being merely optional, and used solely to give a flavour to the beer; hence it is that so many flavours are distinguishable in porter, and that so very few brewers are found to agree with each other in their produce.

Of the articles here enumerated, it is sufficient to observe, that however much they may surprise, however pernicious or disagreeable they may appear, they have always been found requisites in the brewing of porter. They must invariably be used by those who wish to continue the taste, flavour, and appearance, which they have been accustomed to.

DCCCXC.

QUANTITY OF INGREDIENTS NECESSARY FOR *Brewing 5 gallons of Porter.*

One peck of Malt	0	2	6
A quarter of a pound of Liquorice Root bruised	0	0	3
Spanish Liquorice	0	0	0½
Essentia	0	0	2
Colour	0	0	2
Treacle	0	0	1¼
Hops	0	0	6
Capsicum and Ginger	0	0	1
	0	3	10
Coals	0	0	10
Total Expence	0	4	8
This will produce five gallons of good Porter, which bought, would cost . .	0	8	4
But being brewed at home, for . .	0	4	8
Leaves of clear gain	£0	3	8

This saving is enough to pay for time and trouble, and perhaps in London, a woman might not be able to earn, in the same time, one penny; by following this plan, then, every woman will earn something, for according to the Proverb, Money saved is money got.

The Porter will be drinkable in a week, being perfectly wholesome and palatable.

Observations. If it is objected that many are ignorant of the art of brewing; some instructions are necessary; and if they are followed, every person will be convinced of the possibility and propriety of providing a beverage for his family, by a cheaper and more pleasing method than that of resorting to a public house for every pint of beer which the wants of nature may demand.

Every person intending to brew for himself, must be careful to see the malt measured and ground; and not trust to the corn-chandlers, who frequently impose, both in quality and quantity, on those who are so incautious as not to see these things done in their own presence.

The tubs and vessels must be carefully inspected, and proved to be free from dirt or the least taint, as defects of that nature may distaste a whole brewing.

The mash-tub should be particularly attended to, and a wisp of clean hay, or straw, is to be put over the bottom of the vessel in the inside, to prevent the malt running off with the liquor. The malt being emptied into the mash-tub, and the water brought to boil, dash the boiling water in the copper with cold water sufficient to stop the boiling, and leave it just hot enough slightly to scald the finger. Brewers use a thermometer, the first mash being usually taken at 180°, and the second at 190°; but as few persons have a brewing thermometer, the foregoing rule will be found sufficient by a little practice; always remembering to draw off the second mash somewhat hotter than the first. The water being thus brought to a proper temperature by the addition of cold water, lade it out of the copper over the malt till it becomes thoroughly wet, mashing it well to prevent the malt from clotting; when the water is poured on too hot, it *sets* the malt, closing the body of it; and when that happens it is difficult to recover it. It can only be done by adding cold water. By *setting the malt* is to be understood, its closing the body of the grain, instead of opening it so as to dissolve in the liquor. Cover up the mash-tub close to compress the steam, and prevent the liquid from evaporating. In small quantities, this should carefully be regarded; in larger ones it does not signify so much.

Let the wort stand an hour and a half, or two hours, after mashing, then let the liquor run off into a vessel, prepared to receive it; if at first it runs thick and discoloured, draw off one or two pails full, and pour it back again into the mash-tub till it runs clear.

In summer, it will be necessary to put a few hops into the vessel which receives the liquor out of the mash-tub, to prevent its turning sour, which the heat of the weather will sometimes endanger. Let the second mash run as before, and let the liquor stand an hour and a half, then run it off, but never let the malt stand dry; keep lading fresh liquor over it till the quantity of wort to be obtained is extracted, always allowing for waste in the boiling.

The next consideration is *boiling the wort*. The first copper full must be boiled an hour, and whilst boiling, add the several ingredients, except the ginger, and cocculus berries. The hops are now to be boiled in the wort, but are to be carefully strained from the first wort, in order to be boiled again in the second. Eight pounds, is the common proportion to a quarter of malt; but in summer, the weather being hotter, the quantity must be varied from eight pounds to twelve pounds, according to the heat of the air.

After the wort has boiled an hour lade it out of the copper and cool it. In summer, it should be quite cold before it is set to work; in winter, it should be kept till a slight degree of warmth is perceptible by the finger. When properly cooled set it to work, by adding yeast in proportion to the quantity. If considerable, and if wanted to work quick, add from one gallon, to two. Porter should be brought forward quicker than any other liquor except Twopenny; let it work till it comes to a good deep head, then cleanse it by adding the ginger. The liquor is now fit for barrelling. Fill the barrels full, and let the yeast work out, adding fresh liquor to fill them, till they are quite full and have done working. Now bung the barrels, but keep a watchful eye upon them for some time, lest the beer should suddenly ferment again, and burst them, which is no uncommon accident where due care is not taken; the heat of summer, or a sudden change of weather, will occasion the same misfortune, if the barrels are not watched; and eased when they require it, by drawing the peg.

The only part which remains to complete the brewing, is *fining* the beer. To understand this, it is necessary to remark, that Porter is composed by brewers of three different sorts of malt,—pale, brown, and amber;—the reason for using these three sorts, is to attain a peculiar flavour and colour. Amber is the most wholesome, and it is recommended to use none else. In consequence of the subtleness of the essentia, which keeps continually swimming in the beer, Porter requires a considerable body of finings; but should any person choose to brew without essentia, with amber malt, and with colour only, the porter will refine of itself very soon. Some, however, will perhaps follow the exact recipe, and therefore it is necessary to mention that finings are composed of isinglass dissolved in stale beer, till the whole becomes of a thin gluey consistence, like size. One pint is the usual proportion to a barrel, but sometimes two, and even three are found necessary. Particular care must be taken that the beer, in which the isinglass is dissolved, be perfectly clear, and thoroughly stale.

By attending to these directions, any person may brew as good, if not better Porter than they can be supplied with from the public-houses. Many notions have been artfully raised, that Porter requires to be brewed in large quantities, and to be long stored, to render it sound and strong; but experience will prove the falsehood of these prejudices which have their origin with the ignorant, and are cherished by the interested. One brewing under another, will afford ample time for Porter to refine for use, and every person can best judge of the extent of his consumption. Porter is not the better for being brewed in large quantities, except that the same trouble which brews a peck, will brew a bushel. This mode of practice will be found simple and easy in its operation, essentially useful as to health and convenience, and extremely moderate in point of trouble and expence.

DCCCXCI.

PREPARATION OF ALE.

The following is the proportion of ingredients requisite for brewing a barrel of excellent Ale. The same method is to be pursued, in almost every respect, as for the brewing of Porter. The Prices are annexed, in order to shew the absolute saving which may be made in this beverage. Prices fluctuate, but then, the article compounded rises or falls in price accordingly; so that the ratio of saving is always the same.

	£	s.	d.
Malt, 2½ bushels,	0	15	0
Hops, 2 lbs.,	0	3	0
Sugar, just boiled up, allowing for fire and trouble in preparing, 3 lbs.,	0	2	6
Capsicum, 1*d.* Coriander seeds, 1*d.*	0	0	2
Cocculus Indicus, 1*d.* Salt, 1*d.*	0	0	2
	£1	0	10

The Small Beer, after the Ale is brewed, is supposed an equivalent for coals.

	£	s.	d.
A barrel of Ale, 128 quarts, at 8*d.* per qrt., bought at a publican's in London	4	5	4
Ditto, brewed at home,	1	0	10
Clear gain	£3	4	6

Observations. Ale is generally brewed from pale malt; but that is merely an optional point; some persons preferring brown, some amber ales.

The capsicum and coriander seeds are to be boiled in the wort; observe the method of boiling and mashing as in porter; but let ale stand to work two or three days, and beat it up well, once, or twice a-day. When the head begins to fall, cleanse it by adding a handful of salt, and a little flour, mixed up with the Cocculus Indicus; then proceed to barrel it.

DCCCXCII.

PREPARATION OF THE MALT BEVERAGE, DENOMINATED "*Twopenny.*"

Twopenny is an article not formed to keep, and is not likely to be brewed by any persons for their own consumption. The following proportions for one barrel, are inserted, merely to add to general information in the art of brewing.

	£	s.	d.
Malt, 1½ bushel	0	9	0
Hops, 1 lb.	0	1	6
Liquorice root, 1½ lb.	0	1	6
Capsicum, ¼ oz.	0	0	1
Spanish liquorice, 2 oz.	0	0	2
Treacle, 5 lb.	0	1	8
	0	13	11

	£	s.	d.
One barrel of Twopenny, paid for at the publican's, 128 quarts, at 4*d.* per qrt.,	2	2	8
Brewed at home, coals included, . .	0	15	0
Clear gain	£1	7	8

Observations. It is sufficient to observe respecting this liquor, that it requires no storing, being frequently brewed one week, and consumed the next.

The quantity of Capsicum in one barrel of Twopenny, is as much as is commonly contained in two barrels of porter: this readily accounts for the preference given to it, by the working classes, in cold winter mornings.

Twopenny works remarkably quick, and must be carefully attended to, in the barrels.

DCCCXCIII.

Preparation of ten barrels of Table-Beer.

Table-Beer may be serviceable to a large family, and therefore, the estimate is given upon a larger proportion.

	£	s.	d.
Malt one quarter.	2	2	0
Hops, 8 lbs.	0	12	0
Colour, 8 lbs.	0	4	0
Spanish liquorice, 8 ozs, . . .	0	0	8
Treacle, 10 lbs. . . .	0	3	4
	3	2	0
Ten barrels, at 16*s.* per barrel, bought	8	0	0
Ten ditto, brewed at home, . .	3	2	0
Clear gain	£4	18	0

Liquorice root, and other flavouring substances, may be added: what are here inserted are only the most general, and (as some suppose) the indispensible requisites.

General Observations.

The intoxicating qualities of Porter are to be ascribed chiefly to the various drugs intermixed with it. It is evident, some Porter is more *heady* than others; this arises from the greater or less quantity of stupefying ingredients. Malt, to produce intoxication, must be used in such large quantities as would very much diminish the brewer's profit.

Pale malt is most nutritive, it likewise contains more balsamic qualities than the brown malt, which, enduring a greater degree of fire in the kiln, is sometimes so crusted and burnt, that its mealy parts lose a great share of the essential salts, and other stimulating properties.

Amber malt is that which is dried in a middling degree, between pale and brown, and is now much in use, being the most pleasant, and free from either extreme.

Hops are an aromatic grateful bitter, very wholesome, and, undoubtedly efficacious in giving both flavour and strength to the beer. With regard to the quantity of hops, as tastes are different, no regular fixed rule can be given, but every person must be left to adjust, by experience, the quantity which best suits his palate or convenience.

Yeast is necessary to give the liquor that portion of elastic air, of which the boiling deprives it. Without fermentation, or working, no worts, however rich, can inebriate.

Liquorice root is pleasant, wholesome, and aperient; and opposes the astringent qualities of some of the other ingredients; it ought, therefore, to be used, as should Spanish liquorice, which possesses the same properties.

Capsicum disperses wind, and when properly used, cannot be unwholesome; it leaves a warm glow on the stomach, which is perceptible on drinking some beers.

Ginger has the same effect as capsicum; it, furthermore, cleanses and flavours beer. But capsicum being cheaper, is more used; and, by its tasteless, though extremely hot quality, cannot be so readily discerned in beer, as ginger.

Treacle partakes of many of the properties of liquorice. By promoting the natural secretions, it must be a principal means of rendering porter and beer, in general, wholesome. Treacle is also a cheaper article than sugar, and answers the purposes of colour, where the beer is intended for immediate consumption; but, in summer, where a *body* is required to withstand the temperature of the air; and the draught is not quick, sugar alone can give body to porter. Treacle, therefore, is a discretionary article.

Coriander seed, used principally in ale, is warm and stomachic; but when used in great quantity, it is pernicious.

Cocculus Indicus is poisonous and stupefying, when taken in any considerable quantity. When ground into fine powder it is undiscoverable in the liquor, and is but too much used to the prejudice of the public.

Heading: Salt of steel is most proper, but a mixture of alum and copperas, being much cheaper, has obtained the preference. Alum is a great drier, and causes that thirst which some beer occasions; so that the more you drink, the more you want. Alum gives likewise a smack of age to beer, and is penetrating to the palate. The properties of copperas are well known to be dangerous, and therefore need no comment.

Salt is highly useful in all beers; it gives a pleasing relish, and also fines the liquor.

Different conveniences of cellaring will materially affect beer.—If the cellar is bad, brew only for present use. In this case, six weeks will be found a very proper space betwixt brewing and brewing. Where beer is kept too long in a bad cellar, so as to be affected by the heat of the weather, it will putrefy, though ever so well bunged. Hops will not prevent this accident happening to beer; they only prevent its turning sour.

A number of persons, not reflecting upon the influence of the air,—as soon as summer approaches, begin to think directly of brewing ale, which seldom, or never is so good as that brewed in a proper season. For instance, the extreme variations of heat in this country are from 16 to 88 degrees. Now, on brewing at 16 degrees, great care must be taken that it does not get too cold; whereas on brewing at 88 degrees, the operator will hardly be able to get it cold enough, and must take the dead of the night to reduce it down to a medium heat, which should be about 60°. This observation is too striking not to enforce upon every one's mind the necessity of carefulness and attention in this respect.

The effect on wort when working is exactly the same. In cool weather the spirit of the beer is retained, and it is thereby enabled to work the liquor clear; whereas in hot weather, the spirit quickly evaporates, leaving the wort vapid and flat, unable to work itself clear, but keeping continually *on the fret*, till totally spoiled. This is the obvious reason for the use of sugar, prepared for colour, because sugar will bear the heat better than malt; and when thoroughly prepared, possesses such a strong principle of heat in itself, as to bid defiance to the hottest temperature of the air, and to render its turning sour impossible.

As instances of the effect of both: two casks of the same brewing have been sent into one house, the one prepared with colour, and charged 30*s*., and the other without, charged 14*s*.; on tasting both, the cask prepared with colour was very much commended, and the other returned, as not drinkable.

Clean casks are an essential object in brewing good beer. To keep the casks sweet and in order, never allow them to remain open, but whenever the beer is drawn off, bung them up tight with the lees within them. In a good cellar they will never spoil. Should the casks get musty, the following method will remedy the evil. Soak them well for two or three days in cold water, then fill them full of boiling hot water; now put in a lump or two of lime, shake it thoroughly till quite dissolved, let them stand about half an hour, then wash them out with cold water, and they will be clean and sweet.

TO PREVENT BEER FROM GROWING FLAT.

Put into a cask, containing eighteen gallons, a pint of ground malt, suspended in a bag, and close the bung perfectly; the beer will be improved during the whole time of drawing it for use.

TO RECOVER BEER WHEN SOUR.

When beer is become sour, add some oyster shells, calcined to whiteness, or a little powdered chalk. Either of these will correct the acidity, and will make it brisk and sparkling. It should be drank almost immediately afterwards. Some use salt of tartar.

TO BOTTLE PORTER.

It has been supposed by many persons, that in bottling porter there evaporated. When this decoction becomes cool, incorporate with it, by means of a whisk, two drams of Salt of Tartar, and one dram of Cream of Tartar, previously mixed. The whole should now be kept in a warm place. Thus, a very strong Yeast for brewing, distilling, and baking, may be obtained. For the last mentioned purpose, however, it ought to be diluted with pure water, and passed through a sieve, before it is kneaded with the dough, in order to deprive it of its alkaline taste.

Observation. In countries where yeast is scarce, it is a common practice to twist hazel-twigs so as to be full of chinks, and then to steep them in ale-yeast during fermentation. The twigs are then hung up to dry, and at the next brewing they are put into the wort instead of yeast. In Italy the chips are frequently put into turbid wine, for the purpose of clearing it, this is effected in about twenty-four hours.

DCCCXCVIII.

PREPARATION OF YEAST CAKES.

Mr. Cobbett has lately published an excellent method for preparing artificial Yeast. In Long Island, America, the people are in the habit of making *Yeast Cakes*, once a year. These are dissolved and mixed with the dough, which it raises in such a manner as to form it into most excellent bread. The following is the method in which these Cakes are made:—rub three ounces of Hops, so as to separate them, and then put them into a gallon of boiling water, where they are to boil for half an hour. Now strain the liquor through a fine sieve into an earthen vessel, and while it is hot, put in three pounds and a half of Rye Flour; stirring the liquor well, and quickly, as the Flour is put in. When it has become as cool as wort for brewing; add half a pint of good Yeast. On the following day, whilst the mixture is fermenting or working, stir well into it seven pounds of Indian-Corn Meal; this will render the whole mass stiff like dough; this dough is to be well kneaded and rolled out into cakes about a third of an inch in thickness. These Cakes are to be cut out into large disks, or lozenges, or any other shape, by an inverted tumbler or other instrument; and being placed on a sheet of tinned iron, or on a piece of board, are to be dried by the heat of the sun. If care be taken that they are frequently turned, and that they receive no wet or moisture, they will become as hard as ship-biscuit, and may be kept in a bag or box, which is to be hung up, or kept in an airy and perfectly dry situation When Bread is to be made, two cakes of the above mentioned thickness, and about three inches in diameter, are to be broken and put into hot water, where they are to remain all night; the vessel standing near the fire. In the morning they will be entirely dissolved, and then, the mixture is to be employed in setting the sponge in the same way that Beer Yeast is used.

Observations. In making a further supply for the next year, beer or ale yeast may be used as before; but this is not necessary where a cake of the old stock remains,—this acting on the new mixture, in precisely the same way. If the dry cakes were reduced to powder in a mortar, the same results would take place, with perhaps more convenience, and less loss of time. Regarding the employment of Indian-meal; it is used, because it is of a less adhesive nature than wheaten flour; but where Indian-meal cannot easily be procured, white pea-meal, or even barley-meal, will answer the purpose equally well. The principal art, or requisite, in making yeast cakes, consists in drying them *quickly*, and *well;* and in preventing them from coming in contact with the least particle of moisture, until they are used.

* * *

Having described the processes for preparing several malt liquors, as above, it will now be proper to notice the methods used for converting the juices of fruits, &c., into those beverages which are technically known under the appellation of "Home made Wines." These, like malt liquors, are fermented by the addition of yeast.

DCCCXCIX.

CURRANT WINE.

Boil four gallons of spring water, and stir into it eight pounds of honey; when thoroughly dissolved, take it off the fire; then stir it well about, to raise the scum, which take clean off, and cool the liquor.

When thus prepared, press out the same quantity of the juice of red currants moderately ripe, which being well strained, mix well with the water and honey, then put them in a cask, or large earthen vessel, and let them stand upon the ferment, for twenty-four hours; then to every gallon add two pounds of fine sugar, stir them well to raise the scum, and, when well settled, take it off, and add half an ounce of cream of tartar, with the whites of two or three eggs, to refine it. When the wine is well settled and clear, draw it off into a small vessel, or bottle it up, keeping it in a cool place.

Of white currants, a wine after the same manner may be made, that will equal in strength and pleasantness many sorts of white wine; but as for the black, or Dutch currants, they are seldom used, except for the preparation of medicinal wines.

DCCCCV.

MORELLA WINE.

Cleanse from the stalks, sixty pounds of Morella Cherries, and bruise them so that the stones shall be broken. Now press out the juice and mix it with 6 gallons of Sherry Wine, and 4 gallons of warm water. Having grossly powdered separate ounces of Nutmeg, Cinnamon and Mace, hang them separately, in small bags, in the Cask containing the mixture. Bung it down: in a few weeks it will become a deliciously flavoured Wine.

DCCCCVI.

CHERRY WINE.

Take Cherries, nearly ripe, of any red sort, clear them of the stalks and stones, then put them into a glazed earthen vessel, and squeeze them to a pulp. Let them remain in this state for twelve hours to ferment; then put them into a linen cloth, not too fine, and press out the juice with a pressing-board, or any other convenient instrument. Now let the liquor stand till the scum rises, and with a ladle or skimmer take it clean off; then pour the clearer part, by inclination, into a cask, where, to each gallon put a pound of the best Loaf-Sugar, and let it ferment for seven or eight days. Draw it off, when clear, into lesser casks, or bottles; keep it cool, as other wines, and in ten or twelve days it will be ripe.

DCCCCVII.

PEACH AND APRICOT WINE.

Take Peaches, Nectarines, &c. when they are full of juice, pare them, and take the stones out; then slice them thin, and pour over them from a gallon to two gallons of water, and a quart of white Wine. Place the whole on a fire to simmer gently for a considerable time, till the sliced Fruit becomes soft; now pour off the liquid part into another vessel containing more Peaches that have been sliced but not heated; let them stand for twelve hours, then pour out the liquid part, and press what remains through a fine hair bag. Let the whole be now put into a cask to ferment; then add of Loaf-Sugar, a pound and a half to each gallon. Boil well, an ounce of beaten Cloves in a quart of white Wine, and add it, this will give the Wine a delicious flavour.

Wine of Apricots may be made by only bruising them and pouring the hot liquor on them. This Wine does not require so much sweetening. To give it a curious flavour, boil an ounce of Mace, and half an ounce of Nutmegs, in a quart of white Wine; and when the Wine is fermenting pour the liquid in hot. In about 20 days, or a month, these Wines will be fit for bottling.

DCCCCVIII.

Excellent Compound Wine.

An excellent family Wine may be made of equal parts of red, white, and black Currants, ripe Cherries, and Raspberries, well bruised, and mixed with soft water, in the proportion of four pounds of fruit to one gallon of water. When strained and pressed, three pounds of moist Sugar are to be added to each gallon of liquid. After standing open for three days, during which it is to be stirred frequently, it is to be put into a barrel, and left for a fortnight to work, when a ninth part of brandy is to be added, and the whole bunged down. In a few months it will be a most excellent Wine.

DCCCCIX.

Quince Wine.

Gather the Quinces when pretty ripe, in a dry day, rub off the down with a linen cloth, then lay them in hay or straw for ten days, to *perspire*. Now cut them in quarters, take out the cores, and bruise them well in a mashing tub with a wooden pestle. Squeeze out the liquid part, by pressing them in a hair bag, by degrees, in a Cider press; strain this liquor through a fine sieve, than warm it gently over a fire, and skim it, but do not suffer it to boil. Now sprinkle into it some loaf-sugar reduced to powder; then, in a gallon of water and a quart of white Wine, boil a dozen or fourteen large Quinces thinly sliced; add two pounds of fine Sugar, and then strain off the liquid part, and mingle it with the natural juice of the Quinces; put this into a cask, (not to fill it) and mix them well together; then let it stand to settle: put in two or three whites of Eggs, then draw it off. If it be not sweet enough, add more Sugar, and a quart of the best Malmsey. To make it still better, boil a quarter of a pound of stoned Raisins, and half an ounce of Cinnamon Bark, in a quart of the liquor, to the consumption of a third part, and straining it, put it into the cask when the wine is fermenting.

DCCCCX.

Birch Wine.

The season for obtaining the liquor from Birch Trees, is in the latter end of February or the beginning of March, before the leaves shoot out, and as the sap begins to rise. If the time is delayed, the juice will grow too thick to be drawn out. It should be as thin and clear as possible. The method of procuring the juice, is by boring holes in the trunk of the tree, and fixing facets of Elder; but care should be taken not to tap it in too many places at once, for fear of injuring the tree. If the tree is large, it may be bored in five or six places at once, and bottles are to be placed under the apertures for the sap to flow into. When four, or five gallons have been extracted from different trees, cork the bottles very close, and wax them till the Wine is to be made, which should be as soon as possible after the sap has been obtained. Boil the sap, and put four pounds of loaf-sugar to every gallon, also the peel of a Lemon cut thin; then boil it again for nearly an hour, skimming it all the time. Now pour it into a tub, and as soon as it is almost cold, work it with a toast spread with yeast, and let it stand five or six days, stirring it twice or three times each day. Into a cask that will contain it, put a lighted brimstone match, stop it up till the match is burnt out, and then pour the Wine into it, putting the bung lightly in, till it has done working. Bung it very close for about 3 months, and then bottle it. It will be good in a week after it is put into the bottles.

DCCCCXI.

ORANGE WINE.

To six gallons of water put fifteen pounds of soft Sugar; before it boils, add the whites of six Eggs well beaten, and take off the scum as it rises; boil it half an hour: when cool, add the juice of fifty Oranges, and two-thirds of the peels cut very thin; and immerse a toast covered with yeast. In a month after it has been in the cask, add a pint of Brandy, and two quarts of Rhenish Wine: it will be fit to bottle in three or four months, but it should remain in bottle for twelve months before it is drank.

DCCCCXII.

GINGER WINE.

To seven gallons of water put nineteen pounds of clayed Sugar, and boil it for half an hour, taking off the scum as it rises; then take a small quantity of the liquor, and add to it nine ounces of the best Ginger bruised. Now put it all together, and when nearly cold, chop nine pounds of raisins, very small, and put them into a nine gallon cask (beer measure,) with one ounce of Isinglass. Slice four Lemons into the cask, taking out all the seeds, and pour the liquor over them, with half a pint of fresh yeast. Leave it unstopped for three weeks; in about three months it will be fit for bottling.

Observations. There will be one gallon of the sugar and water more than the cask will hold at first: this must be kept to fill up, as the liquor works off; as it is necessary that the cask should be kept full, till it has done working. The raisins should be two-thirds Malaga, and one-third Muscadell. Spring and Autumn are the best seasons for making this wine.

DCCCCXIII.

PARSNIP WINE.

To 12 pounds of Parsnips cut in slices, add 4 gallons of water, boil them till they become quite soft. Squeeze the liquor well out of them, run it through a sieve, and add to every gallon three pounds of Loaf-Sugar. Boil the whole three quarters of an hour, and when it is nearly cold, add a little yeast. Let it stand for ten days in a tub, stirring it every day from the bottom, then put it into a cask for twelve months: as it works over fill it up every day.

DCCCCXIV.

IMITATION OF CYPRUS WINE.

To 10 gallons of water, put 10 quarts of the juice of white Elderberries, pressed gently from the Berries by the hand, and passed through a sieve, without bruising the seeds: add to every gallon of liquor three pounds of Lisbon Sugar, and to the whole quantity two ounces of Ginger sliced, and an ounce of Cloves. Boil this nearly an hour, taking off the scum as it rises, and pour the whole, to cool, in an open tub, and work it with ale yeast, spread upon a toast of bread, for three days. Then turn it into a vessel that will just hold it, adding about a pound and a half of bruised raisins to lie in the liquor till drawn off, which should not be till the Wine is fine.

Observation. This wine is so much like the fine rich wine brought from the island of Cyprus, in colour, taste, and flavour, that it has deceived the best judges.

DCCCCXV.

MEAD:

To thirteen gallons of water, put thirty pounds of Honey, boil and skim it well; then add of Rosemary, Thyme, Bay leaves, and Sweetbriar, about a handful altogether. Boil the whole for an hour; then put it into a tub, with two or three handfuls of ground Malt; stir it till about blood warm; then strain it through a cloth, and put it into the tub again. Now cut a toast, and spread it over with good ale yeast, and put it into the tub. When the liquor has properly fermented, put it into a cask; then take of Cloves, Mace, and Nutmegs, each an ounce and a half; of Ginger sliced, an ounce, bruise the Spices and tie them up in a cloth, and hang it in the vessel; which stop up close for use.

DCCCCXVI.

Cowslip Wine.

Boil five pounds of Loaf Sugar with four gallons of water, simmer them over a fire for half an hour, and when taken off, and cold, put in half a peck of Cowslip flowers, clean picked and gently bruised. Now add two spoonfuls of ale yeast, and a pound of Syrup of Lemons, with a Lemon peel or two. Pour the whole into a well seasoned cask or vessel, let them stand close stopped for three days, that they may ferment well; then put in some juice of Cowslips, and give it a convenient space to work. When it has stood a month, draw it off into bottles, putting a little lump of Sugar into each, by which means it may be kept well for the space of a year. In like manner, Wines may be made of other flowers which possess a pleasant taste and odour, as Oxlips, Jessamine, &c.

DCCCCXVII.

Gilliflower Wine.

To three gallons of water put six pounds of the best raw Sugar; boil the Sugar and water together for the space of half an hour, keep skimming it as the scum rises. Now let it stand to cool, beat up three ounces of Syrup of Betony with a large spoonful of ale yeast, put it into the liquor, and having a peck of Gilliflowers, cut from the stalks, put them in, to infuse and work together for three days, the whole being covered with a cloth; strain it, and put it into a cask, let it settle for three or four weeks, and then bottle it.

DCCCCXVIII.

Mulberry Wine.

On a dry day, gather Mulberries, when they are just changed from redness to a shining black, spread them thinly on a fine cloth, or on a floor or table, for twenty-four hours; and then press them. Now boil a gallon of water with each gallon of juice; putting to every gallon of water, an ounce of Cinnamon Bark, and six ounces of Sugar-candy finely powdered. Skim and strain the water when it is taken off and settled, and put to it the Mulberry juice. Now add to every gallon of the mixture, a pint of White or Rhenish Wine. Let the whole stand in a cask to ferment, for five or six days. When settled, draw it off into bottles, and keep it cool.

DCCCCXIX.

RASPBERRY WINE.

Gather the Raspberries when ripe, husk them, and bruise them; then strain them through a bag into jars or other vessels. Boil the juice, and to every gallon put a pound and a half of Lump-sugar. Now add whites of Eggs, and let the whole boil for fifteen minutes; skimming it, as the froth rises. When cool and settled, decant the liquor into a cask, adding yeast to make it ferment. When this has taken place, add a pint of white Wine, or half a pint of proof spirit to each gallon contained in the cask, and hang a bag in it containing an ounce of bruised Mace. In three months, if kept in a cool place, it will be a very excellent and delicious Wine.

DCCCCXX.

French Method.

Steep two gallons of Raspberries in a gallon of Sack for twenty-four hours, then strain them, and put to the liquor three quarters of a pound of Sun Raisins, well stoned. Let them continue for four or five days, sometimes stirring them well; then pour the liquid off gently, and bottle it up. If not sweet enough, add some Sugar, about half a pound to a gallon will be sufficient; keep it in a cool place.

DCCCCXXI.

DAMSON WINE, &c.

Take a considerable quantity of Damsons and common Plumbs inclining to ripeness; slit them in halves, so that the stones may be taken out, then mash them gently, and add a little water and honey. Add to every gallon of the pulp a gallon of spring water, with a few bay leaves and cloves; boil the mixture, and add as much Sugar as will well sweeten it, skim off the froth, and let it cool. Now press the fruit, squeezing out the liquid part; strain all through a fine strainer, and put the water and juice together in a cask. Having allowed the whole to stand and ferment for three or four days, fine it with white Sugar, Flour, and whites of Eggs; draw it off into bottles, then cork it well, in twelve days it will be ripe, and will taste like weak Port, having a flavour of Canary.

DCCCCXXII.

AMERICAN WINE.

The following was communicated to the public by Joseph Cooper, Esq. of New Jersey.

"I put a quantity of the comb, from which Honey had been drained, into a tub, and added a barrel of Cyder, immediately from the press; this mixture was well stirred, and left for one night. It was then strained before fermentation took place; and Honey was added, until the specific gravity of the liquor was sufficient to bear an egg. It was then put into a barrel; and after the fermentation commenced, the cask was filled every day, for three or four days, that the froth might work out of the bung-hole. When the fermentation moderated, I put the bung in loosely, lest, stopping it tight might cause the cask to burst. At the end of five or six weeks, the liquor was drawn off into a tub; and the whites of eight eggs, well beaten up, with a pint of clean sand, were put into it: I then added a gallon of Cyder Spirit; and after mixing the whole together, I returned it into the cask, which was well cleaned, bunged tight, and placed in a proper situation for racking off, when fine. In the month of April following, I drew it off into kegs, for use; and found it equal to almost any foreign Wine: in the opinion of many judges, it was superior.

Observations. This success has induced me to repeat the experiment for three years; and I am persuaded, that, by using clean honey instead of the comb, as above described, such an improvement might be made, as would enable the citizens of the United States to supply themselves with a truly *federal* and wholesome wine, which would not cost a quarter of a dollar per gallon, were all the ingredients procured at the market price. It would have this peculiar advantage, that it contains no foreign mixture, but is made from ingredients produced on our own farms."

DCCCCXXIII.

KOUMISS; A WINE PREPARED BY THE TARTARS.

Take of fresh Mare's Milk any quantity; add to it a sixth part of Water, and pour the mixture into a wooden vessel. Use as a ferment an eighth-part of sour Cow's Milk; but at any future preparation, a small portion of old

Koumiss will answer better. Cover the vessel with a thick cloth, and set it in a place of moderate warmth; leaving it at rest for twenty-four hours: at the end of which time the Milk will have become sour, and a thick substance will be gathered on its top. Now with a churn chaff, beat it till the thick substance above-mentioned be blended intimately with the subjacent fluid. In this situation leave it at rest for twenty-four hours more; after which, pour it into a higher and narrower vessel, resembling a churn, where the agitation must be repeated as before, till the liquor appear to be perfectly homogeneous. In this state it is called Koumiss; of which the taste ought to be a pleasant mixture of sweet and sour. Agitation must be employed every time before it is used. This Wine is cooling and antiseptic. Sometimes aromatic herbs, as Angelica, is infused in the liquor during fermentation.

DCCCCXXIV.

RAISIN WINE.

Put two hundred weight of Raisins, with the stalks, into a hogshead, and fill it almost with spring Water; let them steep for about twelve days, frequently stirring, and after pouring off the juice, dress the Raisins and mash them. The whole should then be put together into a very clean vessel that will exactly contain it. It will hiss for some time, during which it should not be stirred; but, when the noise ceases, it must be stopped close, and stand for about six or seven months; and then, if it proves fine and clear, rack it off into another vessel of the same size. Stop it up, and let it remain for twelve or fourteen weeks longer; then bottle it off. If it should not prove clear, fine it down with three ounces of Isinglass, and a quarter of a pound of Sugar candy, dissolved in some of the Wine.

DCCCCXXV.

RAISIN WINE EQUAL TO SHERRY.

Let the Raisins be well washed and picked from the stalks; to every pound thus prepared, and chopped, add one quart of Water, which has been boiled and has stood till it is cold. Let the whole stand in the vessel for a month, being frequently stirred. Now let the Raisins be taken from the cask and let the liquor be closely stopped in the vessel. In the course of a month let it be racked into another vessel, leaving all the sediment behind, which must be repeated till it becomes fine, when add to every ten gallons, six pounds of fine Sugar, and one dozen of Seville Oranges, the rinds being pared very thin, and infused in two quarts of Brandy, which should be added to the liquor at its last racking. Let the whole stand three months in the cask, when it will be fit for bottling; it should remain in the bottle for a twelvemonth.

To give it the flavour of Madeira, when it is in the cask put in a couple of green Citrons, and let them remain till the Wine is bottled.

DCCCCXXVI.

GRAPE WINE.

To every gallon of ripe Grapes put a gallon of soft Water, bruise the Grapes, let them stand a week without stirring, and draw the liquor off fine; to every gallon of Wine put three pounds of lump Sugar; put the whole into a vessel, but do not stop it till it has done hissing, then stop it close, and in six months it will be fit for bottling.

A better Wine, though smaller in quantity, will be made by leaving out the Water, diminishing the quantity of Sugar. Water is necessary, only, where the juice is so scanty, or so thick, as in Cowslip, Balm, or black Currant Wine, that it could not be used without it.

Observations. It will be here necessary for the reader's information, to examine the peculiar qualities on which the excellency of several foreign wines depends. Spain and Portugal being those countries of Europe where vines are cultivated in the greatest perfection, and where the most careful attention is paid to the manufacture of the several sorts of wine, we shall in this place take a summary view of each.

SPANISH AND PORTUGUESE WINES.

The wines of Spain are of two descriptions, namely, white and red, and are, for the most part, excellent. The greatest quantities are made in the southern parts of the kingdom, and the sale is very extensive, especially among the English and Dutch. The wines of the Canaries, although not actually Spanish, are to be met with in most of the ports of Spain, and are usually classed with the wines of that country. Although the whole of the Canaries produce excellent wines, the preference is given to those of Parma and Teneriffe. When the vintage proves favourable, Teneriffe annually makes up about 30,000 pipes of Vidonia, or as it is sometimes denominated *Bastard Madeira*, from the similarity of its flavour and appearance to the dry wine of the last mentioned island. Teneriffe also produces a sweet wine, which is nearly similar to Malmsey Madeira.

The wine of Chacoli in Biscay is not of a first rate quality. In order to produce this wine the Biscayans ingraft five or six different vines upon the same stalk. Most parts of Biscay abound in these vines, which border the high roads, generally growing to the height of about three or four feet. The wine in Biscay is sold at a certain price, as regulated by the police, and until the whole produce of the vintage is disposed of, no foreign wine is permitted to be brought into the province; hence it happens that the sole study of the proprietors of vineyards is to collect a large quantity of wine, without attending to quality or flavour, and consequently, *chacoli* has become proverbially despicable in Spain. Indeed, the grapes are not allowed to arrive at a state of maturity, but are gathered and squeezed, while sour and nearly devoid of substance: but, if the juice were allowed to collect and meliorate in the grape, if the green fruit were not mingled with the ripe, if the wines were made with the same care as those of other provinces, this wine would prove equal in every respect (except that of seniority) to the French *champaign*, which, of its kind, stands at present unrivalled.

The wine of Guidas in Castile is made from cherries, and is a species of ratafia. Foucal wine, which takes its name from a village near Madrid, is of a good quality, but is only reckoned ordinary.

The wines of Val de Penas, Ciudad Real, Ribadavia, and Rioxa, and those called La Mancha are very good, and except in regard to different degrees of colour, are similar in every respect.

The best wines of Arragon are those denominated Garnachas, from the species of grape which produces them: the best of all is a red wine named Hospital; it is excellent as to flavour and strength. Caninea, called likewise white Garnachas, is very fine, and is much esteemed.

The wines of Peralta, Tudela, Tafalla, and Arandillo in Navarre, are nearly alike, and are excellent both as to flavour and quality. That of Peralta is well known under the title of Rancio, which it receives when old enough to merit that distinction. To these may be added the wine of Iluesca, which is very good.

The wines of Xeres, better known under the name of Sherry, are made at the town of that name in the province of Andalusia. They are not only dry, but sweet; the dry, however, are the most esteemed, more particularly, when they present a pale straw colour. Many, who are in the habit of tasting Sherry, have doubtless perceived that there is something in its flavour which partakes of the taste of leather; this is owing to the custom of bringing the wines down the country in large leathern vessels, or, as the Spaniards call them, *boots*, whence we derive our term butts, which we bestow upon the casks wherein we receive the wines.

In Andalusia are made sweet and dry wines, called Pagarete and San Lucar, and the strong well known red wine, denominated Tinto Rota, or Tent, which is an excellent stomachic. The Montilla is a dry wine. The territory of Xeres, alone, annually produces above 60,000 pipes of wine.

In the province of Grenada, is made the celebrated wine called Mountain or Malaga. It is dry and sweet, and both red and white. It is truly a delicious wine, and is much esteemed. The sweet Mountain is the most sought after, and is usually employed as a dessert wine. Grenada produces Peroximenes or Pedro Ximenes, which is a very fine flavoured, full bodied wine. There is also a kind of Malmsey made in this province, which is exquisite; but that of Maravella is only an ordinary wine.

In Valentia is found the Tinto Alicante, a wine much used in France; it is sweet when new, but grows thick and ropy as it becomes aged: it is a good stomachic.

The Benicarlo wine is red, dry, and thick; it is often palmed upon the public by wine dealers, as Port wine; to which it is very inferior, both in quality and price. An imposition of this sort is to be avoided, by observing whether the wine offered have a ruby colour instead of a deep black; a generous flavour, and not that harshness which immediately offends a good palate: if not, it assuredly cannot be Port wine. The wine called Siches and that called Garnache, both made in Catalonia, are exquisite. In the same province are made Tinto de las Montanas, or Mountain Tent, and Mataro wine; both of which are sweet, thick, ropy, and unwholesome. The latter is often sold by irreputable traders, to private families, as Tent.

It is almost needless to observe that the wine called Port, of which such vast quantities are consumed in Great Britain, is the produce of Portugal. The vines, whence it is made, grow upon the banks of the Douro, about fourteen or fifteen leagues from Oporto, and occupy a space about six leagues in length, and two leagues in breadth. These vineyards produce between 60 and 70,000 pipes of Port, and there are others which yield nearly 6,000 pipes annually. The vine whence we derive our Port, originally grew in Burgundy, but the climate of Portugal, being widely different from that of Burgundy, has caused such an alteration in the grape, that no two wines are more unlike, than those which are the produce of the above mentioned territories.

The wines of Portugal, like those of Biscay, are only sold at the prices annually regulated by the government. As soon as the prices are promulgated, the factory and individuals send in their names to the proprietors of the wines; the whole of the Port wine is shipped at Oporto.

The Brandy of Spain constitutes a considerable article of commerce; it is very inferior to the brandy of France, and is principally used in making up Spanish and Portuguese wines. The brandy of Portugal is nearly the same as that of Spain, and very little of it is exported.

Notwithstanding the great natural produce of wines, various attempts have been made, and with success, at a *synthetical* preparation of this beverage. It is to be feared, that this practice is sometimes carried on, without regard either to science or humanity. Indeed, there are many compounds sold in London and elsewhere, intended to imitate port and other wines, which agree with them in no character save in colour and astringency; and these, it is known, are given to them by the most pernicious ingredients. But the French, and other chemists, have really produced wines, which possessed all the agreeable properties of those produced from grapes. This was done, by first analysing the wine to be imitated, and then, by apportioning the quantities of the several ingredients which existed in the wine, naturally. In this way, Fabroni made wine, from 864lbs. of sugar, 24lbs. of gum-arabic, 24 of tartar, three of tartarous acid, 26 of gluten of wheat, and 1728 quarts of water. Parmentier made a good Muscadine wine from 216lbs. of sugar, nine pounds of crystals of tartar, 72 of elder flowers, and 307 of water. The colonists in the West Indies, prepare a wine from 250lbs. of sugar, two barrels of water, and four pounds of yeast; this wine is coloured with litmus, and scented with some essential oil.

In addition to these *synthetical* preparations, it may be observed, that others of an analogous, but of a more surprising nature, have recently been effected. Kirchoff, a Russian chemist, discovered that starch may be converted into sugar, possessing all the properties of sugar from grapes, by mixing it with about four times its weight of water, and about one hundredth part of its weight of sulphuric acid. This discovery was confirmed by Saussure, who ascertained that 100 parts of starch became 110.14 parts, when converted into sugar. The same subject being successfully resumed by M. Braconnot, he discovered the important fact, that a sugar similar to that of grapes may be obtained by means of sulphuric acid, from the sawings of wood, old linen, and paper.

In this operation, a certain quantity of these substances is treated with sulphuric acid, concentrated by cold. The mass appears to be carbonised, but this appearance arises from a stratum of black powder which covers it; and which, when removed by washing, is converted into a true gum, resembling gum-arabic. This gum is separated from the sulphuric acid, in excess, by means of carbonate of lime, and it remains in the liquor. By afterwards treating this gum with sulphuric acid, diluted with water, it is converted into true sugar, the quantity of which is greater than that of the sawings of wood, or the linen, employed. In addition to this sugar, which forms almost the whole of the mass, M. Braconnot obtained another substance, which he called the *vegeto-sulphuric acid.* The sugar, in question, was of the consistence of syrup; at the end of twenty-four hours it began to crystallize, and some days after, the whole was condensed into a single mass of crystallized sugar, which was pressed strongly between several folds of old cloth; crystallized a second time, this sugar was passably pure; but treated with animal charcoal, it became of a shining whiteness. The crystals were in spherical groups, which appear to be formed by the union of small diverging and unequal plates. They are fusible at the temperature of boiling water. The sugar is of a fresh and agreeable flavour, producing in the mouth a slight sensation of acidity. Mingled in a proper quantity of water, set in fermentation, and hopped according to the method of brewers, the syrup, above mentioned, furnishes a beer, which is light, brisk, strong, and of an agreeable savour.

After having ascertained that all ligneous matter, such as wood, bark, straw, hemp, &c. may be transformed into gum, and into sugar, by the sulphuric acid, M. Braconnot extended his researches to the parts of animals, and he began with gelatine, as obtained from the skin, membranes, tendons, &c. of animals. He found that gelatine may be converted by sulphuric acid into a crystallisable sugar *sui generis,* which probably does not exist in nature. It crystallises more readily than that from the cane. It is less fusible, and it contains azote. Its sweetness is nearly equal to that of the sugar of grapes. Its solubility in water is not greater than that of sugar of milk, with which it has, at first sight, some analogies. By slow evaporation, it yields crystals as hard as sugar-candy, and in the form of flat prisms or tables grouped together. He also found that the sugar of gelatine combines intimately with the nitric acid, (with sensible decomposition, and even without the aid of heat,) and then forms a new acid, to which he has given the name of the *nitro-saccharic.*

ACETOUS FERMENTATION.

The Acetous fermentation is that which takes place in vegetable infusions containing Saccharine or Mucilaginous matter, at an elevated temperature. It has been shown before, that the Vinous Fermentation takes place at different temperatures between 50° and 70° of Fahrenheit, but, if Saccharine or Mucilaginous liquids are elevated to higher temperatures, a change takes place in the whole mass; and instead of the formation of Alcohol, the generation of Acetic Acid, or Vinegar is induced. This fermentation, or Acetification, is, no doubt, the consequence of a chemical change which takes place in the Mucilaginous or Saccharine principle of the vegetable substance; but upon what play of affinities it depends, chemists have not hitherto determined.

A notable difference exists between the Vinegars made from different substances. The specific gravity of good Wine Vinegar is about 1,025, Water being 1000. Wine Vinegar not only contains Acetous Acid, but also Sulphate of Potass, and Lime; (probably accidental) Extractive Matter, and the Tartaric, Citric, Malic, and Oxalic Acids. The three latter, however, are often wanting even in good Vinegar. The best Wines, as those of Languedoc, Spain, Portugal, and Italy, yield the strongest Vinegar, although too dear for common use.

Various Experiments have been tried on the Acetification of certan substances. We shall here notice some performed by M. Cadet, and other French Chemists.

DCCCCXXVII.

FLOUR AND WATER WITH YEAST.

Seven ounces of Flour boiled in fifty-six ounces of Water, assisted by half an ounce of ferment, and kept working for twenty-four hours, produced as much Vinegar as saturated nine drams of Potass.

Observations. The same quantity of starch, boiled with a similar proportion of water and ferment, kept working for thirty-five days, produced as much vinegar as saturated eleven drams of potass. Although sugar, assisted by yeast, passes, from the alcoholic, to the acetous fermentation, yet the mixture of alcohol with water does not ferment, unless extractive matter, mucilage, or boiled starch, is added, and the alcohol is not too predominant in the mixture.

A solution of sugar-candy did not ferment until one-fifteenth of its weight of yeast was added, and then it fermented readily in the temperature of 68° Fahr. Treacle ferments of itself, provided it is diluted in a sufficient quantity of water. Solution of gum began to become acid very quickly, and its fermentation was promoted by yeast. Extractive matter does not ferment, but becomes putrid. Yeast produces no effect upon extract of liquorice, which seems to contain a saccharine principle. Starch does not ferment by itself; flour ferments with difficulty, and after three or four days the liquid begins to putrefy.

DCCCCXXVIII.

SUGAR AND WATER WITH YEAST.

10 oz. of Sugar, 70 oz. of Water, and 16 drachms of Ferment, began to work the next day, the fermentation lasted 12 days. It required a dram and a half of Potass to saturate 4 oz. of this Vinegar. Eight ounces of the Vinegar yielded 2 drachms of crystallized sugar.

DCCCCXXIX.

SUGAR, ALCOHOL AND WATER WITH YEAST.

5 oz. of Sugar, 5 oz. of Alcohol and 72 oz. of Water with 6 drams of Yeast, began to work the same day; the fermentation lasted 12 days. It required 1 dram of Potass to saturate 4 oz. of this Vinegar. 8 oz. of the Vinegar yielded half a dram of sugar; it tasted very weak, and yielded Alcohol on distillation, with some traces of Acetous Ether.

DCCCCXXX.

EXCESS OF SUGAR WITH WATER

15 ounces of Sugar, 70 ounces of Water, and 6 drams of Yeast, began to work the same day; the fermentation lasted 23 days. It required 2 drams of Potass to saturate 4 ounces of this Vinegar. 8 ounces of it yielded nearly an ounce of Sugar.

DCCCCXXXI.

SUGAR AND WATER, WITH ALCOHOL,

In small Proportion.

10 oz. of Sugar, 5 oz. of Alcohol, 72 oz. of Water, and 6 drams of Ferment, began to work the second day, and continued to do so for 8 days: Carbonic Acid Gas was emitted but the liquor did not redden Syrup of Violets. By distillation, each quart of Vinegar yielded 10 drams of weak Alcohol.

DCCCCXXXII.

SUGAR, GUM, AND WATER, WITH YEAST.

Eight ounces of Sugar, 2 ounces of Gum, 72 ounces of Water, and 6 drams of Ferment began to work the first day; the fermentation lasted 15 days. It required 2 drams of Potass to saturate 4 ounces of this Vinegar. The Vinegar was very strong, and Alcohol being poured in, nearly an ounce of Mucilage was precipitated in a month afterwards.

DCCCCXXXIII.

SUGAR AND WATER, WITH EXCESS OF YEAST.

15 ounces of Sugar, 72 ounces of Water, and 10 drams of Yeast began to work the first day; the fermentation lasted 10 days. It required 2 drams of Potass to saturate 4 ounces of this Vinegar. The same quantity yielded 2 drams of Sugar which had not fermented.

Observations. From these experiments it may be concluded; 1st. That the alcohol added to the fermenting liquors (although it may be partly changed into vinegar,) cannot be substituted for sugar. 2nd. That when the sugar is in too great quantity, part of it does not ferment. 3rd. That mucilage hastens the fermentation, but, like sugar, the superabundant portion remains unaltered. And 4th. That too large a proportion of alcohol prevents fermentation altogether.

M. Cadet tried several experiments, to determine the best proportions of ingredients, to form vinegar. He found the following to be those best adapted to this purpose.

DCCCCXXXIV.

APPROVED PROPORTIONS OF INGREDIENTS

For the best Vinegar.

Eight ounces of Sugar, 57 ounces of Water, and 4 drams of Yeast, began to work the first day; the fermentation lasted 12 days. It required 3 drams of Potass to saturate 4 ounces of the Vinegar produced. This Vinegar was very strong, agreeably tasted, and did not contain, or deposit, any Sugar.

DCCCCXXXV.

DIMINUTION OF THE ABOVE QUANTITY OF WATER.

By diminishing the quantity of water, some of the Sugar remains undecomposed. Seven ounces and 1 dram of Sugar, 28 ounces of Water, and 4 drams of Yeast, did not begin to work till 2 days afterwards; the fermentation lasted 21 days, being very slow. It required only 2 drams of Potass to saturate 4 ounces of this Vinegar. The liquor was still very saccharine, and tasted like simple Oxymel.

DCCCCXXXVI.

APPROVED PROPORTIONS FOR THE CONVERSION OF

Alcohol into Vinegar.

The following proportions appeared most likely to cause Alcohol to be totally converted into Vinegar: 3 oz. 4 dr.

of Sugar, the same quantity of Alcohol, 28 ounces of water, and 4 drams of ferment, began to work two days afterwards; the fermentation lasted 17 days. It required 2 drams of Potass to saturate 4 ounces of this Vinegar, the liquor had a vinous smell, and half the Alcohol employed was separated by distillation.

Observations. Sugar, therefore, is the essential ingredient in the formation of vinegar; mucilage is partly changed into vinegar and accelerates the fermentation, but disposes the liquor to putrefaction, unless prevented by the addition of alcohol. This last is imperfectly changed into vinegar; but it renders the vinegar sharp, makes it keep well, and when used for infusing aromatic plants, takes up the resinous and odoriferous particles.

Mr. Hebert, of Berlin, is said to have made vinegar, in two months, from four parts of rectified malt spirits, and 72 of water; but this experiment did not succeed in France. The vinegar, commonly sold, contains alcohol, and the first portion that comes over is alcoholic. M. Lowitz has separated alcohol from vinegar by freezing, and subsequent distillation from powdered charcoal. The quantity of potass required to saturate a given quantity of vinegar, indicates the quantity of acid which it contains, and the quantity of acid appears to depend upon the quantity of sugar originally contained in the fermented mass. Hence taking the first experiment of 8 ounces of sugar for the basis of the calculation, it appears that the sugar employed in the formation of acetous acid, is to the potass necessary to saturate it, as 1,2668 to 1,0000; from whence there may be calculated the quantity of sugar that ought to be added to any weak vinegar, in order to bring it to any required strength. The same experiment also shows that 100 parts of good vinegar are formed from 12,410 of sugar, 0,799 of yeast, and 86,791 of water, whence the proportion of yeast to be added may be deduced; and on this foundation an estimate may be made of the quantity of saccharine matter contained in a vegetable, when it is so enveloped in other principles, as not to be separable by the ordinary methods. This may be performed by making a decoction of the plant, fermenting the decoction, and saturating the acid with potass. If the decoction reddens litmus, the malic, citric, oxalic, or tartarous acid, contained in it, must be saturated with lime, and the liquor filtered before fermentation.

Vinegar may be made in all places by properly adjusting the quantities of saccharine matter, water, and ferment. Excellent vinegar has been made from cabbage, with the addition of some brandy and sugar. Alcohol may be employed in lieu of some of the sugar, provided it does not exceed the fourth part of this substance. The quantity of sugar that the substance contains ought to be previously ascertained, by fermenting eight ounces of it with 56 ounces of water, and half an ounce of yeast, or baker's leaven, which latter is preferable, because yeast sometimes gives a disagreeable taste to the vinegar. The mixture is to be put into a vessel, one half of which is to be left empty, and kept in a temperature of 68° Fahr. for 25 or 30 days, being stirred morning and evening. The strength of the vinegar, now obtained, being ascertained by adding potass, it will be easy to calculate how much saccharine matter must be added, to form vinegar of the required strength.

In large manufactories it is best to employ small barrels, placed as in saltpetre-houses, in order that their contents may be easily drawn off, and no brass cocks or pewter syphons should be used. The barrels should be placed in a stove, so that all may receive an equal degree of heat, regulated by thermometers placed in different parts of the building.

DCCCCXXXVII.

COMMON METHOD OF MAKING VINEGAR.

To every gallon of water put a pound of coarse Lisbon sugar; let the mixture be boiled, and skimmed as long as any scum arises. Then let it be poured into proper vessels; and when it is as cool as beer, when worked, let a warm toast, rubbed over with yeast, be put to it. Let it work about twenty-four hours, and then put it into an iron-hooped cask, fixed either near a constant fire, or where the summer sun shines the greater part of the day; in this situation it should not be closely stopped up; but a tile, or something similar, should be laid on the bung hole, to keep out the dust and insects. At the end of about three months (sometimes less) it will be clear, and fit for use, and may be bottled off. The longer it is kept, after it is bottled, the better it will be. If the vessel containing the liquor is to be exposed to the sun's heat, the best time to begin making it, is in the month of April.

DCCCCXXXVIII.

GOOSEBERRY VINEGAR.

Bruise the Gooseberries, when ripe, and to every quart put three quarts of water; stir them well together, and let the whole stand for twenty-four hours, then strain it through a canvas bag.

To every gallon of liquor add one pound of brown sugar, and stir them well together before they are put into the cask. Proceed in all other respects, as before. This Vinegar possesses a pleasant taste and smell; but Raspberry Vinegar which may be made on the same plan, is far superior in these respects. The Raspberries are not required to be of the best sort, still, they should be ripe, and well flavoured.

DCCCCXXXIX.

PRIMROSE VINEGAR.

To 15 quarts of Water put 6 pounds of brown sugar; let it boil ten minutes, and take off the scum: pour on it half a peck of Primroses; before it is quite cold, put in a little fresh Yeast, and let it work in a warm place all night; put it in a barrel in the kitchen, and when done working, close the barrel, still keeping it in a warm place.

DCCCCXL.

VINEGAR FROM THE REFUSE OF BEE-HIVES.

When honey is extracted from the combs, by means of pressure, take the whole mass, break and separate it, and into each tub, or vessel, put one part of combs and two of water; place them in the sun, or in a warm place, and cover them with cloths. Fermentation takes place in a few days, and continues from eight to twelve days, according to the higher or lower temperature of the situation in which the operation is carried on. During the fermentation, stir the matter from time to time, and press it down with the hands, that it may be perfectly soaked. When the fermentation is over, put the matter to drain upon sieves or strainers. At the bottom of the vessels, will be found a yellow liquor, which must be thrown away, because it would soon contract a disagreeable smell, which it would communicate to the vinegar. Then wash the tubs, put into them the water separated from the other matter; it immediately begins to turn sour; when the tubs must be again covered with cloths, and kept moderately warm. A pellicle, or skin, is formed on their surface, beneath which the vinegar acquires strength; in a month's time it begins to be sharp; it must be left standing a little longer, and then put into a cask, of which the bung hole is left open. It may then be used like any other vinegar.

Observation. To strengthen vinegar, suffer it to be repeatedly frozen, and separate the upper cake of ice, or water, from it.

All vinegars owe their principal strength to the acetic acid they contain; but the vinegar of wine contains also tartar, a small portion of the malic acid, alcohol, and colouring matter; that of cider and perry contains merely the malic acid, little or no alcohol, and a yellowish colouring matter.

PANARY FERMENTATION.

This species of fermentation, (which has been termed panary, from the Latin *panis*, bread), is that which is induced in a mixture of flour and water by yeast, in the making of bread. Bread which has undergone this fermentation, is termed Leavened Bread, to distinguish it from that in which there has been no chemical change. Sea biscuits, and other hard bread of a similar nature, also that used by the Jews at the time of their Passover, come under the denomination of Unleavened Bread, whilst that prepared by the bakers for common use, is denominated Leavened or Loaf Bread, from being prepared with yeast.

The addition of yeast to flour and water in making bread, is, doubtless, the cause of improving it greatly; for without it, this article of food would be hard, heavy, and indigestible.

Although the fermentation of dough has been termed *panary*, there is little doubt but it is merely a modification of the acetous. The subjects of both species of fermentation are certainly different, in regard to consistency, but it is probable, that the modification alluded to, is the consequence of this difference: for, the fermentible matter, from want of room for action, does not arrive at the same point of chemical change, which it would do in a more diluted state. We shall not attempt to theorize on the changes which take place during the panary fermentation, further, than to suppose that the flour, yeast, and water, give out their elementary components for the formation of Saccharine matter, Starch, Carbonic acid, and Acetic acid; and that during the incipient generation of the latter, the process is stopped by the action of artificial heat. The loaf retains its shape and bulk, from the innumerable cells formed in it by the Carbonic acid. The walls of these cells being suddenly hardened by the heat, (the Carbonic acid being doubtless driven off,) they retain their shape, and the loaf thus remains spongy. It sometimes happens, from various causes, but especially from cold, that the fermentation is checked; when this is the case, the dough is technically said to *set*; and the consequence is, that when baked, the bread is disagreeable, heavy, and unwholesome. To prevent *setting*, bakers in winter give the dough a sufficient temperature, by shutting the doors to prevent the admission of cold air, and by placing the leaven near the door of the oven.*

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* We have before hinted regarding the pernicious respiration of carbonic acid gas, in manufactories. It is to be feared, that in bake-houses, this gas is more plentifully inhaled than is either necessary, or proper. It is well known, that in order to be able to supply the public with fresh bread for breakfast, bakers are in the habit of working all night About 11 o'clock at night, they make the *sponge* or dough, which, of course, must have some time for fermentation; whilst this is taking place, the baker, who has perhaps slept little during the day, indulges himself now; and as he is fearful of not awaking in time to work the sponge into loaves, and of baking it in the oven; he hits upon the following ingenious, but pernicious expedient. He knows, that the dough in the trough is every minute becoming more spongy, from the incessant action of the ferment. This enlargement of bulk will, of course, raise

Leavened bread is chiefly made from wheaten flour, of various degrees of fineness, though potatoes and rice flour are frequently, and with advantage, used in its preparation. In London the quantity of potatoes used in the best baker's bread, is from 10 to 15 pounds to every sack of flour. The finest flour is seldom, or never, used in making loaf bread: it is always employed in making biscuits and pastry. The coarser sorts therefore being made into loaves, there are two kinds with which the public are supplied: these are *standard* wheaten, and brown, or, *household* wheaten bread. The latter, consisting of all the constituents of the wheat, is considered the most wholesome, when the grain has been good from which the flour was ground. It is this bread which is generally used among the English farmers. Each pound of the flour, used in its preparation, consists of ten ounces and six drams of starch, four ounces of bran, one ounce of gluten, and two drams of sugar. The same proportion of ingredients does not, of course, exist in those sorts of wheaten flour from which the bran, &c. has been separated.

But, as the fine, or the whitest flour, is that which fetches the highest price, and as people generally imagine that the whitest loaf contains the greatest quantity of nutritive matter, it has always been an object with the bakers, to render the coarsest flour white enough to be used in making the standard wheaten bread. But, for this purpose, the most unjustifiable means have been used: regarding the use of potatoes and rice, there can be no possible blame attached to them; but when plaster of Paris, chalk, and alum, are resorted to, the trade of a baker may be justly denominated one that is injurious to society. Besides the occasional use of the two former mineral substances, it is here confidently asserted, that each inhabitant of London, generally, at every meal, swallows 22 grains of alum,[*] in the bread which he eats. There are

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or resist any weight placed upon the dough; consequently the lid of the trough, and any weight laid upon it, will be elevated, when the fermentation has arrived at that point, at which it may be divided into loaves. The baker, therefore, considering a similar elevation of his own body as a sufficient check on somnolency, lays himself down to sleep upon the lid of the trough; the consequence is, that he is certainly aroused from his unhealthy slumbers at the required period; but his constitution is sure to suffer from the immense body of carbonic acid gas which is liberated during the fermentation.

[*] This assertion is not made without proper evidence. In addition to other undoubted authorities, a tradesman who deals in salt, alum, &c., and who is in the habit of furnishing bakers with these articles, informed

some cases, where even more alum than the quantity here specified, enters into the composition of bread.

DCCCCXLI.

Preparation of Bread,

According to the Method practised by the London Bakers.

A Sack of flour being sifted into the kneading-trough, to make it lie loose; six pounds of salt, and two pounds of alum, are separately dissolved in hot water, and the whole (in the quantity of a pailful) being cooled to about 90° Fahr., is mixed with two quarts of yeast. When this mixture has been well stirred, it is strained through a cloth or sieve, and is then poured into a cavity made in the flour. The whole is now mixed up into a dough, and a small quantity of flour being sprinkled over it, it is covered up with cloths, and the trough-lid is shut down, the better to retain the heat. The fermentation now goes on, and the mass becomes enlarged in bulk. In the course of two or three hours, another pailful

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the Author, that he supplies each of his customers, every night, with two pounds of alum, and six pounds of common salt. These quantities they use for each sack of flour. The employment of salt in bread is attended with great advantages to health, but that of alum is truly pernicious: and what is worse, it yet remains to be proved whether even the very appearance of bread (as to colour) is improved by the use of this astringent salt. Even bakers, themselves, acknowledge that it hinders fermentation, by *killing the yeast*. They say, likewise, that to counteract its effects, they use the potatoes: that is, to promote the fermentation which has been checked by the alum. But, in order to demonstrate that the quantity of alum, above specified, is actually swallowed by bread-eaters, we need only reduce the two pounds of alum to grains; and supposing that a quartern-loaf is eaten (at an average) at eight meals, first, multiply the number of quartern-loaves produced from a sack of flour, by 8; and, secondly, divide the number of grains of alum by the product, thus:—A sack of flour generally produces 86 quartern-loaves; which, multiplied by 8 meals, produces 688 portions:—2 pounds of alum being multiplied by 16, become 32 ounces; these multiplied by 8, become 256 drams; and this product again multiplied by 60 is convertible into 15360 grains. If, then, we divide the latter of these numbers by the former, the quotient will be 22 and a fraction, thus:—

688)15360($22\frac{14}{43}$ grains of alum in the composition
1376 of an 8th part of a quartern-loaf.

1600
1376

$16)\frac{224}{688}(\frac{14}{43}$

of warm water is well mixed with the sponge, and it is again covered up for about four hours. At the end of this time, it is to be kneaded for more than an hour, with three pailsful of warm water. It is now returned to the trough in pieces, sprinkled with dry flour, and at the end of four hours more, it is again kneaded for half an hour, and divided into quartern, and half-quartern loaves. The weight of a quartern-loaf, before baking, should be 4 lbs. 15 ounces; after baking, 4 lbs. 6 ounces avoirdupois. When the dough has received its proper shape for loaves, it is put into the oven, (the heat of which is about 450° Fahr., or that which will scorch flour, without burning,) where it is baked two and a half, or three hours.

DCCCCXLII.

Preparation of Household Bread.

Four ounces of salt are dissolved in three quarts of water, and mixed with with a pint of yeast. This mixture is poured into a cavity made in a peck of coarse, or second flour, placed in a trough. When properly kneaded and fermented, it is divided into pieces of a certain weight, and baked in an oven.

Observation. Sometimes, a portion of rice flour, or boiled potatoes, or rye meal, is mixed with the flour, in the farm-houses, previous to kneading the dough. The rye and rice serve to *bind* the bread, but the potatoes render it light and spongy.

DCCCCXLIII.

Method of producing one-third more Bread,

From a given Quantity of Corn.

Boil a bushel of the coarsest bran for about an hour, in six or seven gallons of water, (keeping it well stirred that it may not stick to the bottom of the copper,) then pour off the whole into a trough, or tub, perforated full of holes; over which may be laid a coarse cloth, to act as a sieve. On the top of the whole, should be placed a wooden cover, having a heavy weight placed thereon, to press out all the liquor from the bran; which will then be left at the bottom of the tub, in a thick pulp. The liquor that will be expressed, will contain all the essential oil of the corn, and will be of the consistency of paste, having a very agreeable taste and smell, similar to the milk that is found in green corn. The next thing is, to apply this liquor or mixture to the purpose of making the dough, being careful not to mix raw water therewith, as it will set the mixture. The proper quantity of bread being made, it will be found to weigh, when completely baked, full one-third more than the same quantity of flour, made simply with water in the usual way.

Observations. In domestic establishments, in the country, this method is peculiarly applicable, where corn is sent to the mill from the consumer; and it is not necessary to make any calculation, or point out the saving to the public, even by a partial adoption of this plan. Was it generally carried into effect, it would be equal to bringing six hundred thousand acres of land into the cultivation of bread corn.

DCCCCXLIV.

BREAD MADE OF ICELAND MOSS, WITH FLOUR.

Of late years, Iceland moss has been used (either alone, or mixed with flour,) in the composition of bread, in those districts where flour does not exist in plenty. The authorities of Saxony published a report on the subject, in which we are informed that 7 lbs. of *lichen meal* boiled with fourteen times its quantity of water, and baked in this state with 59½ lbs. of flour, produced 111½ lbs. of good household bread. Without this addition, the flour would not have produced more than 78¾ pounds of bread.

To prepare this bread on a smaller scale, use the following quantities.—It is known that three pounds of flour yield four pounds of household bread; one pound of lichen meal, added in the form of paste, will give an addition of nearly six pounds, and therefore is equivalent, in this view, to about 3¾ lbs. of flour, because it affords above 3½ times more bread.

Observation. Nearly all the Iceland moss collected in Germany, is sent to England, where it is used in brewing, and in the composition of ship biscuit. Biscuit which contains it, as a constituent part, is not attacked by worms, and suffers little from the action of sea water. This lichen, when deprived of its bitter principle, forms an excellent soup; and when coagulated, a good jelly.

DISTILLATION.

The object of distillation is the preparation of Spirituous, and other Volatile liquors. These consist of Alcohol or pure spirit, which is obtained from any spirituous liquor; Brandy, Rum, Arrack, and Whisky, prepared from Wine, Sugar, Rice, and Malt; Compound Spirits, or those which, in addition to Alcohol, contain some volatile or pungent oil or essence—as Gin, Hollands, Carraway, and Peppermint;

the Essential Oils, as Oil of Cinnamon, Oil of Cloves, Oil of Peppermint and Otto of Roses; and the simple Distilled Waters, which retain the fragrant flavour of the particular herbs, with which they have been distilled. The necessary apparatus for Distillation have already been exhibited, and described, in the fourth Chapter of this work. We shall here detail the several modes of operation, which are commonly adopted, for the distillation of liquors, strongly impregnated by Alcohol or ardent spirit. Although Brandy, Rum, Arrack, Geneva, Malt-spirits, &c. differ much in colour, taste, smell, and other properties, the spirituous part, or Alcohol, is the same in all: their peculiar properties depending, generally, upon the presence of some Essential Oil, and Water, in varied proportions.

Previous to the operation of distilling, those of brewing and fermentation are necessary. The fermentation ought always to be carried on as slowly as possible, and performed in vessels closely stopped, only having at the bung a valve pressed down by a spring, which will yield with less force than is sufficient to burst the vessel. It should even be suffered to remain till it has become perfectly fine and transparent; as by this means the spirit will not only be superior in quantity, but also in fragrance, pungency, and vinosity, to that otherwise produced.

With regard to performing the operation of distilling, there is only one genreal rule that can be given, namely, to let the heat, in all cases, be as gentle as possible. A water-bath, if sufficiently large, is preferable to any other mode, and will perform the operation with all the dispatch requisite for the most extensive business.* As the end of rectification is to make the spirit clean, as well as strong, or to deprive it of the essential oil, as well as of the aqueous part, it will be proper to have regard to this, even in the first distillation. For this purpose, the spirit, as it first comes over, should be received into a quantity of cold water; as by this means the connection between it, and the oily matter, will be considerably lessened. For the same reason, after it has been once rectified in the water-bath, it should be again mixed with an equal quantity of water, and distilled a second time. Thus, the spirit will be freed from most of the oily matter, even though it has been very much impregnated with it, at first. After the spirit has been distilled, once or twice, in this manner from water, it may be distilled in a water-bath without any addition; and this last rectification will free it from the greater part of the water which it may contain. In distilling compound spirits, a small still has been found to answer better than a large one.

A distiller's apparatus should be erected in an out-building, to prevent any hazard which might arise from fire:—spirituous liquors being remarkably combustible. If such an accident should occur, a woollen blanket, or rug, hung over a roller in a water butt, is the readiest and best extinguisher. Let the distillery be large enough, not only in regard to the room required for the still, the worm-tub and the pump, (which should be all ranged together,) but also, that the spirits and wash, &c. may be contiguous to the still, for the convenience of filling or charging it. Room is likewise required for empty vessels, tubs, casks and other utensils. The still-house floor should be paved, or flagged, with a considerable descent for carrying off by gutters the waste wash from the still, and the water which has become hot, (and consequently useless) in the worm tub or refrigeratory. It is absolutely necessary, that the pump should afford a sufficiency of water, to supply the still, to cool the worm, and to dilute the spirits (to a certain degree) after distillation. The still if of a middling size, should be placed upon a furnace of brick-work, having a fire-place 24 inches long, 9 inches wide, and 22 inches high.

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* See description of Mr. Tritton's still, Chapter 4th.

Let the still-cock come so far through the brick-work, that the wash may run out, either into cans, or otherwise, as there is conveniency for conveying it away. The brick-work about the still must be exactly round, as high as the upper nails of the still, (sloping from the flame lest any liquor boil over,) and well mortared; also covered all round with coarse canvass or hop-sack, to keep the wall from cracking.

The worm-tub must be placed very near the still, upon a strong wooden frame according to its size, which must be six or eight times the capacity of the still, so that every stave may rest firmly upon the frame; the better to support the great weight of such a quantity of water, as is necessary for keeping the worm constantly cold. The worm-tub frame must be so high, that when the tub is placed upon it, the low end of the worm which comes through the tub, will admit of the cans being readily placed under, and taken away when they are full. The upper end of the worm must be placed so, that the arm of the still-head may go into it, without any difficulty, and shut so close as to be easily luted; and the tub must stand so upright, that no liquor may remain in the worm; this may be known by putting a pint or quart of water into the worm, which will run out at the lower end of it. In the middle of the worm tub, place a wooden gutter three or four inches square within, to reach from the top to the bottom, having about three or four inches on the opposite sides, at the bottom end of it, left open; so that the cold water pumped into the gutter, may flow out at the two breaches to the lower part of the worm-tub. This will force all the hot water to ascend and run either over the worm-tub; or through a waste pipe, soldered in the tub, and extending down the sides, to convey it away. The pump must be placed next the worm-tub, and must be of such a height that the spout, or cock, may reach the gutter fixed in the middle; so that the water may be more easily, and with less waste, conveyed into the tub to cool the worm. There should, also, be another spout or cock in the pump, rather lower, for drawing water for all common uses; the higher spout being closed, and only appropriated for cooling.

It will be necessary likewise to have a large back, set upon a strong frame, to command the worm tub, and to contain a large quantity of water, having a large brass cock communicating with the still, &c. This will be of very great service on any emergency; and may be drawn off in much less time, and with less trouble, than by pumping; for the still may accidently be dry, which would be productive of danger if there were not a quantity of water ready at hand.

It will be convenient to have a middle sized press, fixed firmly in a corner of the distillery. It should have a strong bed, to contain the articles to be pressed. There should also be six hair-clothes somewhat wider than the press, to be put between the layers of cherries, elderberries, raspberries, &c. to be acted on The fruit should be placed in thin layers; the juice will run off by a spout affixed to the press, into one of the cans placed under it.

In a distillery, are required a variety of utensils, such as three or four iron-bound tubs, capable of containing from a hogs-head, to a pipe, of any liquor; three or four cans, capable of holding from two to six gallons by measure; these should have brass or other marks in their necks, to which they should be filled; the marks are intended to determine the quantity of liquor. Another necessary utensil, is an iron-bound wooden funnel, which by computation will hold three or four gallons, having a strong iron nosel, or pipe, to put into the bung holes of the casks.

In some convenient part of the distillery must be placed a pretty large vessel, either covered or open, with a cock in it, in which all after-runnings, washings of casks, drippings of the cocks, and goods accidentally spoiled, either by wrong mixture, or otherwise; may be kept.

The contents, when in sufficient quantity, may at any time be put into the still, and purified.

Another necessary utensil, is a strong copper or tin pump, five feet long, and six inches in circumference; its nosel about six inches from the top of the pump, and about fourteen inches long. The use of this pump, with its appurtenances, is to draw the spirits out of the pieces, into the cans, to charge the still with; and for many similar purposes. A pewter syphon is likewise requisite; it should be made somewhat semilunar, about six feet and a half long, and four inches in circumference. This instrument is employed to draw spirits from any vessel, where the pump cannot play.

Flannel bags are very necessary in a distillery, for refining the thick and feculent matter, at the bottom of casks, and other vessels. These bags are each made of a yard of coarse flannel, sloped so as to have their bottoms narrow, and their tops as wide as the flannel will admit. In shape they resemble inverted cones. They are to be well sewed up at the sides; and their upper parts are to be folded round wooden hoops and well fastened to them. The hoops being perforated in several places, may be suspended by cords from the ceiling.

In Chapter IV. are several directions for preparing lutes, whereby the joints of a distilling apparatus, may be so closed, as to prevent the escape of the spirits.

When the still is charged, let the fire under it be lighted; and whilst it burns up, the joints should be carefully luted. The fire should be of coals, which give a more uniform and lasting heat than wood. In Scotland, peat, or turf, is used for this purpose; and it is said, that the spirits distilled by such fires, possess a peculiar flavour arising from this practice.

By laying the hand on the still and capital, as the fire gains strength, the process of the operation will be ascertained; for, whenever the head, or capital, feels hot, it is a proof that the volatile particles have arisen, and are about to enter the worm. When the still-head is about to become hot, prepare a *damp* made of the ashes under the grate, mixed with as much water as will properly wet them. This mixture is to be thrown upon the fire, to moderate its action, at the instant when the distillation has commenced. By this precaution, the violence of the fire will be abated: otherwise, the spirits would come through the worm, in a rushing stream, and very foul; whereas, it should be quite limpid, and of the size of a goose quill. When one or two cans have been filled with the spirit from the worms end, there is little danger from the fire, which may now be permitted to burn bright and strong. Continue the heat as long as the distilled liquid is spirituous to the taste. It must be recollected, however, that the whole of the distilled liquid is not of the same quality; that which comes over first, being more strongly impregnated with alcohol, than that which runs off towards the conclusion of the process. These are of course to be kept separate. The weak, when in sufficient quantity, may be re-distilled alone, or it may be put into the still with the next charge. When the distilled liquor carries with it any particular flavour, it should be redistilled with essential oils, in order to convert it into a compound spirit, as gin, peppermint, and other cordials.

When all the spirituous fluid is drawn off, the still should be emptied by a cock in the side. The head, &c. should then be removed, and the several lutes taken clean off. The still may now be charged a second time and luted; and then the process is to be carried on as before. If the spirits or compound to be made, is of a different nature, or flavour, from that procured by the last distillation, the still, capital, and worm, should be thoroughly cleaned by hot water, sand, and a scrubbing brush, to remove the oily particles which adhere to their internal surfaces. The worm is best cleansed by passing hot water through it repeatedly, until the water flows out quite flavourless.

It conduces much to the good quality of compound spirits, when the ingredients of which they are composed, are infused in spirits all night, before distillation. Let all these be bruised, sliced, or otherwise separated before infusion.

Great care should be taken that no grease, tallow, soap, or any other unctuous matter fall into the tubs, pieces, rundlets, or cans. All these will injure the appearance of the spirits, causing a flatness, which prevents the rising of those bells, or globules, which are characteristic of strong spirit.

Above all things, lighted candles, torches, or papers, should not be brought near any vessel containing spirits. The flue, or chimney, should be kept constantly clean, both to prevent conflagration, and to preserve the draught of the fire clear.

In dulcifying, or sweetening the spirits, weigh the sugar and dissolve it in one or more cans of the water, with which the compound is to be made up: bruise the sugar, and stir it well, till all is dissolved. Then empty it into the cask, containing the spirits; mixing all together, by drawing off several cans by the cock, and emptying them into the casks by the bung holes. Now rummage all well together, till they are perfectly compounded.

Spirits, or Compounds, that are strong, require no assistance in setting, and becoming clear; but those that are weak must be refined by the addition of some other substance. To every hogshead of Geneva, or other spirituous compound, put six ounces of powdered alum, previously dissolved in three or four gallons of the compound: stir all well together. In the course of twenty-four hours, the whole will be rendered completely clear.

It is a good practice to leave the bung holes of casks, (containing spirits, or compounds newly made) open for several days: this improves their flavour, and renders them clear, sooner than they would otherwise be.

It is an error to suppose that the spirits will be injured, or weakened, by this practice, as the quantity, which, by any possibility, will evaporate from so small an aperture, is comparatively trifling with that of the whole contents of the cask.

It has been repeatedly proved that table-salt, thrown into the still, in the proportion of six ounces to ten gallons of any liquid to be distilled, will greatly improve the flavour, taste, and strength of the spirit. The viscid matter will be fixed by the salt, whilst the volatile matter ascends in a state of great purity. But some even suppose, that the quantity of alcohol, produced by the addition of salt, is greater than when distilled without it: and a distiller in Copenhagen, some time since, published an account, that having several times distilled brandy and gin, from wheat steeped in salt water, he constantly obtained nearly two-twenty-sevenths more of spirits, than from an equal quantity of wheat not so steeped.

The flavour of malt spirits is said to be highly improved, by putting three ounces and a half of finely powdered charcoal, and four ounces and a half of ground rice, into a quart of spirits, and letting it stand during fifteen days, frequently stirring it; then let the liquor be strained, and it will be found nearly of the same flavour as brandy.

A great desideratum among distillers, in this country, is to imitate foreign spirits, such as brandy, rum, geneva, &c. to a tolerable degree of perfection; but notwithstanding the many attempts that are daily made for this purpose, the success, in general, has been indifferent. The general method of distilling brandies, in France, differs in nothing from that practised here with malt-wash or molasses; nor are the French distillers in the least, more cleanly in their operations. Still, though brandy is distilled from wine, experience tells us, that there is a great difference in the grapes from which the wine is made. Every soil, every climate, every kind of grapes, varies with regard to the quantity and quality of the spirit distilled from them. A large quantity of brandy is distilled in France during the time of the vintage; for the poor grapes that prove unfit for wine, are usually first gathered, pressed, their juice fermented, and instantly distilled. This rids them of their poor wines at once, and leaves their casks empty for the reception of better. It is a general rule with them, not to distil wine that will fetch any price *as wine;* for, in this state, the profits obtained are much greater, than when the wine is reduced to brandies. The large stock of small wines, with which they are almost over-run in France, sufficiently accounts for their making such vast quantities of brandy in that country, more than in others which lie in warmer climates, and are much better adapted to the production of grapes. Nor is this the only source of their brandies; all the wine that turns bad is condemned to the still; and also, all that they can neither export, nor consume at home.

The Arabian physicians used brandy in the composition of medicines, but Alexander Tassoni relates that the Modenese were the first in Europe, who, on occasion of too abundant a vintage, made and sold brandy in considerable quantities. The German miners had first acquired the habit of drinking it; and the great consumption of, and demand for this liquor, soon induced the Venetians to participate with the Modenese in this new branch of commerce. Brandy did not come into general use till towards the end of the fifteenth century, and even then it was called *burnt wine*. The first printed book which makes mention of brandy, recommended it as a preservative against most diseases, and as a means to prolong youth and beauty!

For a long time, this liquor was distilled only from spoilt wine, and afterwards, from the dregs of beer and wine; and, when instead of these, the distillers employed rye, wheat, and barley, it was considered as a wicked and unpardonable misuse of corn: it was for a considerable period the received opinion in France, that brandy distilled from the lees of wine or the husks of grapes, was injurious to the health of those who drank of it; in consequence of which, it was forbidden to distil brandy from such ingredients, under pain of a heavy fine, and the destruction of the still, &c. The fallacy of this opinion, however, was exposed by an order of council, in July 1784, which gave permision to make brandy both from the lees of wine, and from the husks of grapes.

The French brandies are acknowledged to be the best in Europe, those of Nantes and Poitou, of which the qualities are pretty similar, are the most esteemed, as well on account of their excellent flavour, as their peculiar fineness and strength; which latter is such, that they bear the head-proof longer than any other spirituous liquor. It is of these brandies, therefore, that the greatest quantity is exported. The brandies of Anjou, Touraine, Orleans, &c., although not exactly equal in quality to the brandies of Nantes and Poitou, are excellent. Nantes, alone, annually ships from seven to eight thousand barrels of brandy, and Bourdeaux nearly double that quantity.

The mode in which the merchants of the French ports purchase their brandies, is as follows: they write to the distillers to send them samples of certain qualities of brandy, (all of which are distinguished by numbers;) the samples are accordingly forwarded in phials; on receiving them, the merchant briskly strikes the bottom of each phial with his open hand, which causes the bubbles, or beads, to appear on the surface of the liquor. By their size, and duration, he forms his judgment of the respective strength of each sample. If the beads be small, and quickly disappear, the brandy is weak; and *vice versa*. A practice has prevailed, for some time, among several of the French distillers of adulterating their brandies, to make them bear a head, by mixing with them a certain quantity of strong barley-sugar; but this gives the liquor such a degree of harshness, as cannot but be perceived, on tasting it. Genuine brandy invariably possesses a smooth vinous flavour, and does not bite the tongue in the same manner as the adulterated liquor.

DCCCCXLV.

IMITATION OF COGNIAC BRANDY.

English spirits, with proper management, are convertible into Brandy that shall hardly be distinguished from the foreign, in many respects, provided the operation is neatly performed. The best, and indeed the only method of imitating French brandies to perfection, is by an *essential oil of wine*; this being the very ingredient which gives the French brandies their flavour. It must, however, be remembered, that in order to use even this ingredient to advantage, a pure *tasteless spirit must first be produced*; for it would be absurd to expect, that this essential oil should be able to give the agreeable flavour of French brandy to our malt spirit, already loaded with its own oil, or strongly impregnated with a lixivious taste from the Alkaline salts used in rectification.

To prepare the oil of wine, dissolve some cakes of dry wine-lees in 6 or 8 times their weight of water, distil the liquor by a slow fire, and separate the oil by a separatory glass, reserving for the nicest uses that which comes over first, the succeeding oil being coarser and more resinous. This oil of wine may be dissolved in Alcohol; by which means it will, for a long time, be fully possessed of all its flavour; but otherwise it will soon grow rancid.

The essential oil, however, must be drawn from the same kind of lees as the Brandy, to be imitated, was procured from: that is, in order to imitate Cogniac Brandy, it will be necessary to distil the essential oil from Cogniac lees; and the same for any other kind of Brandy. For as different brandies have different flavours, and as these flavours are entirely owing to the essential oil of the grape, it would be preposterous to endeavour to imitate the flavour of Cogniac Brandy with an essential oil procured from the lees of Bourdeaux wine. After the flavour of the Brandy is well imitated by a proper dose of the essential oil, and the whole reduced into one simple and homogeneous fluid, other difficulties still remain: the colour, the proof, and the softness, must also be regarded, before a spirit that perfectly resembles Brandy can be procured. With regard to the proof, it may be easily accomplished, by using a spirit *rectified above proof;* this, after being intimately combined with the essential oil of wine, may be reduced to a proper standard by distilled water The softness may, in a great measure, be obtained by distilling and rectifying the spirit over a gentle fire; what is wanting in this criterion, when the spirit is first made, will be supplied by time: for it must be remembered, that it is time alone that gives this property to French brandies, as at first they are acrid and fiery. Treacle, or burnt sugar, gives the spirit a fine colour, nearly resembling that of French brandy; but as its colour is deep, a large quantity must be used. This is not, however, attended with any bad cousequences; for notwithstanding that the spirit is really weakened by this addition, yet the bubble-proof, (the general criterion of spirits,) is greatly heightened by the tenacity imparted to the liquor by the treacle. The spirit acquires from the mixture a sweetish or luscious taste, which renders it very agreeable to some palates. A much smaller quantity of burnt sugar, than of treacle, will be sufficient for colourin; the same quantity of spirits: the taste also is very differentg for, instead of the sweetness imparted by the treacle, the spirit acquires from the burnt sugar an agreeable bitterness, and, by that means, recommends itself to many who dislike a luscious spirit. The burnt sugar is prepared by dissolving a proper quantity of sugar in a little water, and scorching it over the fire till it acquires a black colour.

Observations. The spirit distilled from molasses, or treacle, is very pure. It is made from common treacle dissolved in water, and fermented in the same manner as the wash for the common malt spirit. But if some particular art is not used in distilling this spirit, it will not prove so vinous as malt spirit, but more flat and less pungent, (though otherwise much better tasted,) as its essential oil is of a less offensive flavour. Therefore, if fresh wine-lees, abounding in tartar, are well fermented with molasses, the spirit will acquire a greater vinosity and briskness, and approach much nearer to the nature of foreign Brandy. If the molasses-spirit, brought to the common proof-strength, is found not to have sufficient vinosity, it will be proper to add some sweet spirits of nitre; and if the spirit has been properly distilled by a gentle heat, it may, by this addition only, be made to pass, with ordinary judges, as French brandy. Great quantities of this spirit are used in adulterating foreign brandy, rum, and arrack. Much of it is also used, alone, in making cherry-brandy and other cordials by infusion; in all which, many, and perhaps with justice, prefer it to foreign brandies. Molasses, like all other spirits, is entirely colourless when first extracted; but distillers always give it, as nearly as possible, the colour of foreign spirits.

DCCCCXLVI.

British Brandy.

To sixty gallons of clean rectified spirits, put one pound of sweet spirit of nitre, one pound of cassia buds ground, one pound of bitter almond meal, (the cassia and almond meal to be mixed together, before they are put to the spirits,) two ounces of sliced orris root, and about thirty, or forty, prune stones, pounded; agitate the whole well together, two or three times a day, for three days or more; let them settle, then pour in one gallon of the best wine vinegar; and add to every four gallons, one gallon of foreign brandy.

DCCCCXLVII.

Process of preparing Gin, in Holland.

The grist is composed of ten quarters of malt, ground considerably finer than our malt-distillers' barley-grist, and three quarters of rye-meal; or, more frequently, of ten quarters of rye and three quarters of malt meal. The ten quarters are first mashed, with the least quantity of cold water it is possible to blend it with, and when uniformly incorporated, as much boiling water is added as forms it into a thin batter; it is then put into one, two, or more casks, or gyle tuns, with a much less quantity of yeast than is usually employed by our distillers. Generally, on the third day, the Dutch distillers add the malt or rye meal, prepared in a similar manner, but not before it comes to the temperature of the fermenting wash; at the same time adding as much yeast as at first.

The principal secret is the management of the mashing part of the business, in first thoroughly mixing the malt with the cold water, and in subsequently adding the due proportion of boiling water, that it may still remain sufficiently diluted after the addition of the fine meal; also in well rousing all together in the back, that the wash may be dilute enough for distilling, without endangering its burning to the bottom of the still. Thus, they commodiously reduce the business of brewing, and fermenting, to one operation. By using cold water uniformly to wet the malt, all danger of clogging is necessarily avoided. By diluting the wash thin enough to be fermented and distilled together, (by which means the spirit of the bran and husky part, as well as of the flour of the grain, are completely extracted,) the Dutch distillers obtain more spirit from their grain than we do, and of a better quality, with not half the trouble taken by our distillers. Their stills usually contain from three, to five, hundred gallons each; they constantly draw off three cans of phlegm, after the runnings cease to burn on the head of the still, when distilling wash; and five cans when distilling low wines. This practice we are unacquainted with, as we usually draw the fire as soon as the runnings from the still burn languidly on the still-head. This, and the great quantity of rye the Dutch use, renders their spirit so much more acid; and the diluteness of their wash is a very good reason for the great purity, and quantity, of their spirit.

To every twenty gallons of spirit, about the strength of proof-spirit, they add three pounds of juniper-berries, with two ounces of Oil of Juniper, and distil by a slow fire: this produces the best Rotterdam gin. An inferior kind is made with a less proportion of berries, sweet-fennel seeds, and Strasburgh turpentine, without a drop of juniper oil. This compound, and a better sort (but inferior to the Rotterdam gin,) are made at Weesoppe.

Observations. In Consett's Travels in Sweden, we are informed that grain is not the only ingredient used in that country for the distillation of spirits. He says, "The low priced Brandies, and Gin, are made from rye, and *ants,* a species of insect very plentiful in this country. Upon inquiry, I find that these ants supply a resin, an oil, and an acid, which have been deemed of considerable service in the art of physic. The ant, used upon these occasions, is a remarkably large black insect, commonly found in small round hillocks, at the bottom of the fir-tree. It is less to be wondered, that they should use these insects in their distilleries, than that they should eat them, and consider them as highly palatable and pleasant."

DCCCCXLVIII.

DISTILLATION OF RUM IN THE WEST INDIES.

In the still-house, as well as in the boiling-house, the greatest cleanliness is necessary; the vats, (at the beginning of the harvest,) ought to be well washed out, with both warm and cold water, to divest them of any filth which may have adhered to their bottoms and sides, since they were last in use.

At first, a greater proportion of skimming from the sugar-pans must be used, than will afterwards be necessary, as the distiller has no good lees, and very little molasses to add to the mass; besides, the skimmings, at the commencement of the season, are not so rich as they will be in March, April, and May, which are esteemed the best yielding months. The following proportions will succeed well in the beginning: for every hundred gallons, the vat contains, put forty-five gallons of skimmings, and five gallons of molasses, to fifty gallons of water. When there are good lees, (or returns, as they are commonly called,) mix equal quantities of skimmings, lees, and water, and for every hundred gallons, add ten gallons of molasses. When the mill is going, and therefore, when there are no skimmings. mix equal parts of lees and water, and for every hundred gallons add twenty gallons of molasses. From liquor set in these proportions, the distiller may expect to obtain from ten, to fifteen, per cent. of proof rum, and other products. But the quantity of spirit will depend greatly on the quality of the ingredients, and in some measure on the weather; therefore an intelligent distiller will vary his proportions accordingly.

Rum differs from what we simply call sugar spirit, as it contains more of the natural flavour, or essential oil, of the sugar-cane; hence it is generally thought, that the rum derives its flavour from the cane itself.

When a sufficient stock of materials is got together, the West-India distillers add water to them, and ferment them in the common method. The fermentation, however, is always carried on very slowly at first; because at the beginning of the season for making rum, in the islands, the distillers want yeast to make it work; but after this, they, by degrees, procure a sufficient quantity of the ferment, which arises up as a head to the liquor in the operation; and thus they are able afterwards to ferment, and make their rum with a great deal of expedition, and in very large quantities.

When the wash is fully fermented, the distillation is carried on in the common way, and the spirit is made up proof, though sometimes it is brought to a much greater degree of strength, nearly approaching to that of alcohol. It is then called double distilled rum.

Observations. It would be easy to bring the spirit to a much greater degree of strength than we usually find it, if it did not bring over in the distillation so large a quantity of a gross oily matter, which is often so disagreeable, that the rum must be suffered to lie by a long time, to become mellow, before it can be used.

The best state to keep rum, both for exportation and other uses, is, doubtless, in that of alcohol, or ardent spirits. In this manner, it would be contained in half the bulk it usually is, and might be let down to the common proof strength with water, when necessary.

What is termed sugar-spirit, is extracted from the washings, skimmings, dross, and waste of the boiling-house. These are to be diluted with water, fermented in the same manner as molasses or wash, and then distilled in the common method. If the operation be carefully performed, and the spirit well rectified, it may be mixed with brandies, in large proportion, to great advantage; for this spirit will be found superior to that extracted from treacle, and consequently more proper for these uses. In Barbadoes a very good spirit of this kind is prepared from the cane juice, called cane spirit, resembling very pure rum.

DCCCCXLIX.

IMITATION OF JAMAICA RUM.

To imitate Jamaica Rum, it is necessary to procure some of the tops, or other parts of the Sugar Canes, and to put them in a still, in the proportion of a pound weight to two gallons of pure flavourless spirit, and one gallon of pure water. The distillation may be carried on by a brisk heat, provided there is a quantity of common salt, (in the proportion of an ounce to each gallon of liquid in the still,) to prevent the mucilaginous matter from arising with the spirit.

The product when rectified and coloured by burnt sugar, will possess every character of excellent Rum.

DCCCCL.

SPIRITS DISTILLED FROM CARROTS.

In France, spirits have been largely distilled from the fermented juice of the Potatoe, and Potatoe Apple, and in England from Carrots. Of the experiments with the latter vegetable substance, Dr. Hunter of York, who performed them, has given us the following interesting account.—"I took one ton and eight stone of Carrots, which, after being exposed a few days to dry, weighed 160 stone. After being washed, topped, and tailed, they lost in weight eleven stone. The whole being cut, I put one-third of the quantity into a copper, with twenty-four gallons of water, and after covering them up close, the fire was lighted underneath, which in three hours reduced the whole into a pulp. The other two-thirds were treated in the same manner, and as the pulp was taken from the copper, it was carried to the press, where the juice was extracted with great facility. The liquor obtained amounted to 200 gallons, and was of a rich sweet taste, resembling wort. It was then put into the copper with one pound of hops. It was suffered to boil about five hours, when it was put into the cooler. Here it remained till the heat came down to 66 degrees. From the cooler it was discharged into the vat, where six quarts of yeast were put to it, in the usual manner. It continued to work forty-eight hours, during which time the heat gradually decreased, contrary to what is observed in other liquors during fermentation. At this time it was at 58°, when the yeast began to fall. I then heated twelve gallons of unfermented juice, and putting it to the liquor, the heat was raised to 66°. It worked afresh for twenty-four hours longer, the liquor gradually lowering, as before, from 66° to 58°. The yeast now beginning to fall, the whole was tunned into half-hogsheads, where it continued to work from the bung. During the progress of the fermentation, the air in the brewhouse was at 46° and 44°. As the liquor in the vat seemed to lose heat hourly, instead of gaining it, I thought it right to keep a fire in the place during the whole time of fermentation. After standing three days in the casks, the liquor was thrown into the still, and fifty gallons drawn off. This was rectified the next day, without any additional substance, and twelve gallons of spirit were obtained."

Observations. "The refuse of the carrots weighed forty-eight stone, which, added to the tops and tails, made provision for hogs. To this should be added the wash from the still, which measured about 114 gallons. In this instance, the *refuse* of an acre of carrots greatly exceeds that of an acre of barley, which is a valuable consideration where hogs are kept. By my experiment, an acre of carrots, (20 tons) will produce 240 gallons of spirit. This is considerably more than what can be obtained from five quarters of barley, which I consider as an equal produce. I estimate the cultivation of an acre of carrots at £10, in which sum I include rent, ploughing, weeding, and all expences; and as far as I am able to guess, the expence of fermentation and distillation will amount to about £15 more. So that estimating the spirit at three shillings and sixpence per gallon, unexcised, the profit will be £17 per acre, to be divided between the grower and manufacturer, exclusive of what is produced by the refuse, which, in large distilleries would make a considerable part of the profit."

DCCCCLI.

USQUEBAUGH.

Usquebaugh is a very celebrated cordial. There are different ways of making it, but the following is the most preferable.

Take of nutmegs, cloves and cinnamon, each two ounces; of the seeds of anise, carraway, and coriander, each four ounces; liquorice-root, sliced, half a pound; bruise the seeds and spices, and put them together with the liquorice into the still, with eleven gallons of proof spirits, and two gallons of water; distil with a pretty brisk fire. As soon as the still begins to work, fasten to the nosel of the worm two ounces of English saffron, tied up in a cloth, that the liquor may run through it, and extract all its tincture. When the operation is finished, sweeten with fine sugar.

Observation. This cordial may be much improved by the following additions: Digest 4 pounds of stoned raisins, 3 pounds of dates, and 2 pounds of sliced liquorice root, in two gallons of water, for 12 hours. When the liquor is strained off, and has deposited all sediment, decant it gently into the vessel containing the Usquebaugh.

DCCCCLII.

LAVENDER SPIRIT.

Take fourteen pounds of Lavender flowers, ten gallons and a half of rectified spirit of wine, and one gallon of water; draw off ten gallons by a gentle fire; or, which is much better, by a sand-bath heat.

Observations. To convert this into the red liquid known by the name of Compound Lavender Spirit:—Take of lavender spirit above described, two gallons; of Hungary water, one gallon; cinnamon and nutmegs, of each three ounces; and of red saunders, one ounce; digest the whole for three days in a gentle heat, and then filtre it for use. Some add saffron, musk, and ambergris, of each half a scruple; but those are now generally omitted.

DCCCCLIII.

HUNGARY WATER.

Take of the flowery top, with the leaves and flowers of rosemary, fourteen pounds; rectified spirit, eleven gallons and a half; water, one gallon; distil off ten gallons by a moderate fire.

Observations. This is called Hungary water, from its being first made for a princess of that kingdom. Some add lavender flowers, and others florentine orris-root; but what is most esteemed, is made with rosemary only.

DCCCCLIV.

CINNAMON CORDIAL.

Take eight pounds of fine cinnamon, bruised; seventeen gallons of clear rectified spirit, and two gallons of water. Put them into the still, and digest them twenty-four hours by a gentle heat; after which, draw off sixteen gallons by a pretty strong heat.

Observation. The proportion of ingredients and products in this, and the foregoing operations, may be reduced to any desired point.

CHAPTER XX.

PRESERVATIVES AGAINST ANIMAL AND VEGETABLE PUTREFACTION, &c.

General Observations.

ALL Animal and Vegetable substances possess properties which constitute what is called life; and when these cease to exist in those substances, their remains become subject to decay and putrefaction, or, in other words, to *Chemical decomposition*.

In all ages, proficiency in the art of preserving certain substances from decomposition, has been a desirable object; and we find that in every country, this art has been practised in a certain degree. In Egypt it was carried to so great a pitch of improvement, as to stamp upon the Ancient inhabitants, a character for perfection in the arts, unrivalled by any other nation, ancient or modern. The *art of embalming* dead bodies so as to prevent decay for several thousand years; amazes, whilst it defies the most ingenious speculations of modern chemists. Nor was this art confined to what is now termed the old world, it was also practised by the ancient inhabitants of the great Continent of America. In the Nitre caves of Kentucky, a female Mummy has been lately found in a most complete state of preservation. This curiosity, which had no doubt been immured in its vast Sepulchre for many ages, is now in the New York Museum. Other ancient nations, too, have been in the habit of curing and preserving Animal substances according to various methods, some of which are now practised by the moderns, and others are perhaps for ever buried in oblivion.

The known processes for the conservation of animal and vegetable substances, are *desiccation*, and the use of *corrective means*. Desiccation is the art of drying animal and vegetable substances, so that their qualities shall not be destroyed by being kept in their, otherwise, natural state; for when perfectly dry, and in certain degrees of temperature, they are not liable to decomposition. On this principle vast quantities of Salmon are annually conveyed in a frozen state to London from the north of England and Scotland;[*] and the inhabitants of the still more Northern regions constantly preserve their food, by freezing it, unchanged through the longest winters.[†] The gelatinous and other soluble parts of animal substances, when extracted by boiling, and kept in a soft moist state, very readily putrefy. But if the same matter be dried by a gentle heat, and secluded from moisture and air by being kept in bottles or metallic cases, it will remain very long without decay. On this principle is made that well-known and useful substance, portable soup. In the burning climate of Africa, when it is intended to preserve a dead animal for food, all that is necessary is to cut the muscular parts into thin strips, from which, in a few hours, the heat of the sun exhales all moisture, reducing them to a substance like leather or horn, which proves to be unsusceptible of future decay from putrefaction. So also, entire human bodies, buried in the arid sands of those countries, have often been found converted, by exhalation and absorption of their natural moisture, into a dry hard sort of mummy, incapable of any further change from the agency of those causes, to which, in such situations, they are exposed.

Similar causes produce the same effects on wood, as in the roofs and other timber of large buildings, which continue for an astonishing length of time unchanged; witness the timber of that noble edifice Westminster-hall, built by Richard II. in 1397; and the more extraordinary instance quoted by Dr. Darwin, in his ingenious work the Phytologia, of the gates of the old St. Peter's church in Rome, which are said to have continued without rotting from the time of the emperor Constantine to that of Pope Eugene

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[*] During the greater part of the season, the fish are sent fresh to the metropolis packed in ice: for this purpose they are laid on their backs in boxes about four feet long and eighteen inches deep, the ice, which is previously broken in small pieces, (about the size of bay salt) is then put over them and beaten down as hard as can be done without bruising the salmon, after which the lid is put on, and in this manner they are kept perfectly fresh for a fortnight or three weeks.

[†] It is related in an account of some voyage to the north seas, that one of the crew having died was buried several feet in the earth. Several years afterwards, the same ship having sailed in those seas, the crew had the curiosity to dig the grave of their comrade, when they found the body in the same frozen state in which it was interred.

IV. a period of eleven hundred years. On the other hand, wood will remain for ages with little change, when continually immersed in water, or even when deeply buried in the earth; as in the piles and buttresses of bridges, and in various morasses.

Among the methods employed for preserving animal substances, the one in most common use is the action of heat, and wood or turf smoke. Both these are applied to flesh and fish. Another principle has also been lately applied to this important subject of domestic economy; viz. the use of Acid Gases, which have been proved to be highly antiseptic. In like manner, Sugar, Sea-salt (Muriate of Soda,) Alcohol, Acids, exert their action, chiefly in absorbing humidity, for which they have a sort of vehement appetency. Salt in but small quantities, only hastens putridity: and *Parmentier* has observed, that in proportion to its purity, or tendency to attract the aqueous vapours of the atmosphere, it will be of service for the preservation of Meat.

Pyroligneous Acid, or what is generally termed *Vinegar of Wood* is that which promises to be of most use as an animal antiseptic. From its low price, it is adapted for general use; more particularly, as it not only preserves the food from putrefaction, but also gives to it that smoky and Acid taste peculiar to well dried hams and red-herrings. Indeed, the only difference in using this Acid, and drying by turf or wood-smoke, seems to be merely the mode of operation; for in both cases this Acid is the agent employed. In one case, the animal substance is acted on during the distillation of the Acid; and in the other, the already formed Acid is applied to the substance by immersion.

This Acid, the product of the distillation of Wood, is now well known in Britain as an article of commerce, and in its native state is a liquid of the colour white Wine possessing a strong Acid and slightly astringent taste, combined with an empyreumatic smell. When allowed to remain in a state of rest for eight or ten days, tar of a black colour subsides, and the Acid is then comparatively transparent. To purify it further, it undergoes the process of distillation, by which it is freed from a still greater portion of the tar with which it is combined, and is thus rendered still more transparent. But though the process of distillation be repeated without end, it will never be freed from the volatile Oil with which it is combined and which is the cause of the empyreuma constantly attending it.* In short it contains the same properties for the preservation of animal matters from putrefaction as smoking them by wood does, which is practised at present by the most barbarous nations, and which has been handed down from the remotest ages of antiquity.

DCCCCLV.

PREPARATION OF PYROLIGNEOUS ACID.

Place a large cast-iron Cylinder, or retort (similar to those used for the production of Carburetted Hydrogen Gas,) in a furnace, so that it may receive as much heat, all round, as possible. One end of this Cylinder must be so constructed as to open and shut, to admit wood and exclude the air.

Oak in pieces about a foot in length is to be put into the Cylinder, which is to be filled as full as possible, without being wedged, and the door must be shut close to exclude air; from the Cylinder let a worm run through cold water to condense the Acid; by this it is conveyed to a large cask placed on one end where there is a pipe to carry it from that to two or three more; thus it is completely secured from flying off in the vaporous state. The fire is now to be raised to a great heat, sufficiently powerful to convert the wood completely into Charcoal. When the Acid ceases to come over, the fire is to be taken out, and the mass of wood left to cool in the confined state, when it becomes perfect Charcoal. In the first cask Tar is chiefly contained with the Acid, it precipitates to the bottom, and is drawn off by a cock; it is afterwards boiled in an iron boiler to evaporate the Acid, before it is fit for use. If the Acid is not strong enough, it is put into large square vats about six inches deep, for the purpose of making a large surface, to evaporate a part of the water contained in the Acid more speedily by a slow heat. These vats are bedded on sand upon the top of a brick stove, where a gentle heat is applied; thus it may be procured in a pretty strong state.

Observations. At the recent anniversary of the Whitehaven Philosophical society, two specimens of meat cured with the pyroligneous acid were exhibited by one of the members. They were prepared on the 7th of Sept. 1819. One had been hung up at home, and the other had been sent out by a vessel to the West Indies, to try the effect of climate upon it, and brought back on the return of the ship to that port. They were tasted by all present, and pronounced to be perfectly sweet, fresh, and fit for use, after a lapse of 15 months.

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* Mr. Stotze, apothecary at Halle, has discovered a method of purifying vinegar from wood, by treating it with sulphuric acid, manganese, and common salt, and afterwards distilling it over. For this method he has obtained a prize from the Royal Society of Gottingen. This gentleman has likewise verified the method proposed by Prof. Meineke in 1814 of preserving meat by means of vinegar from wood, and by continued treatment with the same acid, has converted bodies into mummies.

Besides its antiseptic use, this acid is employed instead of acetate of lead (sugar of lead) by the calico printers, to make their acetate of alumine or iron liquor. Though it is not sufficiently pure, it does well enough for blacks, browns, drabs, &c. but for yellows or reds it is not so good, owing to the oil and tar which is in combination with it.

DCCCCLVI.

ENGLISH METHOD OF CURING BEEF AND PORK.

The following method was for many years successfully practised by an eminent curer of Provisions in London, both for exportation and home consumption. It was communicated by this gentleman to the Editor of the Commercial Magazine.

"To 112 pounds (1 cwt.) of Beef or Pork, take 10 pounds of common salt, and half-a-pound of salt-petre. Let the meat be well cleaned from those particles of blood which will hang about it when cut into four pound pieces; this is best done by washing it in salt and water, or any weak offal pickle, provided it be sweet. Lay the meat in rows, and rub the upper side moderately with salt, then lay another layer of meat, and repeat the operation as on the first layer; in this manner, continue the same proportion of salt and saltpetre, till you have the quantity you wish to cure, all heaped up in a tub, or some other vessel (not of lead) in order to preserve the pickle from issuing from it. In this state it must remain for three days, then turn it into another tub, sprinkling it with salt as you turn it; when all is turned, let the pickle procured by the first salting, be gently poured about the meat. In this state let it remain for a week, and it will be excellent for home use.

Should it be wanted for exportation, pack it in this state into such casks as your order may express. But as the greatest care for its keeping good, abroad, consists in the packing, you must first put a layer of salt in the barrel, then a layer of meat packed very close, (with your hands only) and in this manner the cask must be filled up. When headed, you must carefully filter the pickle through a coarse cloth, (not boil it) and when perfectly fine, fill up the cask by the bung-hole. In this state let it remain till the next day, in order to observe whether the cask be tight or not, then bung it up. By this method I have never found myself deceived in one single instance, in its keeping any reasonable length of time. The too great rubbing of meat will not keep it the better, it frequently retards the operation of the salt by filling the outward pores of the meat only to the destruction of the middle of the piece, which frequently perishes."

Observations. Dr. Mitchell of Philadelphia is of opinion that when meat is salted, a decomposition takes place in the following manner, viz. The septic acid of the meat unites with the soda of the salt, forming septate of soda, whilst the muriatic acid combines with the animal fibre, forming muriate of Fibrine. Regarding the quality of the salt to be used, the following extract from a report of a Committee of the House of Commons, may be worthy of attention.

"The *common* salt we are informed by an Irish Member, is employed only *prior* to the packing of the beef, the *bay* salt is used *in* the packing, thus both are employed but for different purposes, or at least in different branches of the art of salting beef: the British salt is not used in packing the beef, because having undergone the process of boiling, *it is apt in warm countries, to melt and slip from between the interstices of the beef*, and thus fail in the object of keeping it. The Irish beef has obtained its character of keeping so well in various parts of the world, from the *bay* salt with which it is cured."

Bay salt is a kind of brownish impure salt, obtained in France, Italy, and other countries, by evaporating sea-water in pits. The principal part, however, of the bay salt which is sold in Great Britain, is of home manufacture, being a coarse grained crystallized salt, made dirty by powdered turkey umber, or some such colouring material, to imitate the foreign article. The only utility which this salt appears to possess, beyond that of the common fine-grained salt universally found in the shops, is, that it dissolves more slowly by moisture, and therefore is better calculated for the salting of fish, and other animal matter, which cannot be wholly covered with brine.

Basket salt is made from the water of the salt springs in Cheshire and other places. It differs from the common brine salt in the fineness of the grain, as well as on account of its whiteness and purity. It is principally used at table.

Not only is Muriate of Soda an agreeable and wholesome seasoning for man, but almost all herbivorous animals like it, and it appears to be very salutary for them.

Lord Somerville attributes the health of his flock of 203 Merino sheep, which he purchased in Spain, principally to the use which he has made of salt for the last seven years on his farm. These sheep having been accustomed to the use of salt in their native land, his lordship considered, that in this damp climate, and in the rich land of Somersetshire, it would be absolutely necessary to supply them with it regularly. A ton of salt is used annually for every 1000 sheep: a handful is put in the morning on a flat stone or slate, ten of which, set a few yards apart, are enough for 100 sheep. Twice a week has been usually found sufficient. Of a flock of near 1000, there were not ten old sheep that did not take readily to it, and not a single lamb which did not consume it greedily. Salt is likewise a preventive of disorders in stock fed with rank green food, as clover or turnips, and it is deemed a specific for the rot. Horses and horned cattle are also very fond of salt: the cow gives more and richer milk, when salt is mixed with her food. The wild beasts of the forests in America, at certain seasons, leave their haunts, and travel in bodies to various places where salt is to be found. These places are called *Licks* from the practice which these animals have of licking the ground on which the salt lies, or which is strongly impregnated by it.*

The importance and value of salt as a corrective of food, becomes daily more evident, as its medicinal properties are rendered more fully known. Among others, may be mentioned its anthelmintic properties, Whenever salt is denied to the human being, diseases of the stomach are general, and worms are engendered in the body. In some instances, where persons from aversion to this substance, have refused it either in food, or in any other form, worms have been engendered, and have been with great difficulty got rid of.

In Ireland, salt is a well known common remedy for bots in the horse; and among the poor people, a dose of common salt is esteemed a cure for the worms. It is supposed by some medical men, that salt furnishes soda to be mixed with the bile: without this necessary addition, the bile would be deprived of the qualities necessary to assist in the operation of digestion.

One of the greatest grievances of which the poor man can complain is the want of salt. Many of the insurrections and commotions among the Hindoos, have been occasioned by the cruel and unjust monopolies of certain unworthy servants of the British East India Company; who, to aggrandise their own fortunes, have oftentimes bought up, on speculation, all the salt in the different ports and markets, and thus have deprived the ingenious but wretched natives of their only remaining comfort, viz. salt; the only addition they are usually enabled to make to their poor pittance of rice! many of the poor in England have loudly lamented the high price of salt, which thousands are in the habit of using as the only sweetener of their meal of potatoes.

Salt is also of the greatest use in Agriculture; from one to two bushels is about sufficient for each acre of land; but this quantity is, of course, to be varied according to the quality of the soil. This answers better than almost any other manure. The Chinese have for ages been accustomed to manure their fields by sprinkling them with sea water.

Salt has some other uses. The Persians sprinkle the timber of their buildings with salt, to prevent them from rotting. It is used in Abyssinia, instead of money; it passes there from hand to hand, under the shape of a brick, worth about eighteen pence.

It appears very probable that the vitrified fossile pillars in which the Abyssinians enshrined the mummies of their ancestry, according to Herodotus, were nothing more than masses of *salgem*, a substance very common in that part of Africa.

Considering the many uses of muriate of soda in agriculture and the arts; and as a necessary article of food and preservative from putrefaction, it may be pronounced one of the most generally useful and necessary to man of all the minerals; and it is truly lamentable, that in almost all ages and countries, (particularly in those where despotism has obtained a footing,) this should be one of those necessaries of life, on which the most heavy taxes are imposed.*

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* Cattle fed on grass which grows on the sea-shore, are always fatter and in better condition than those which graze on inland pastures.

Muriate of *magnesia*, as well as muriate of soda, has been proved to possess most powerfully antiseptic qualities, and is well known to be a constituent of sea-water. It would be well worth trial by a course of experiments, to discover whether, these salts separately, or conjointly, possess the property of retarding putrefaction in the greatest degree.

DCCCCLVII.

PRESERVATION OF ANIMAL FOOD FROM PUTREFACTION

By Charcoal.

Tin canisters, (whose tops were made to slide in grooves, in the act of opening and shutting,) were filled with charcoal fumes (carbonic acid gas) to expel the Atmospheric air. Alternate layers of Charcoal and slices of meat were then put in, so that each cannister was at length quite full: one with mutton, another with beef, and a third with pork. The lids were now luted carefully, and a bladder was pasted over the top of each. The cannisters were put into a wine cellar in the month of April, where they remained until December, a period of 8 months. When they were opened, the meat was found to be perfectly sweet, and of as good a colour as any at the butchers: some of the slices were dressed and eaten, and were pronounced excellent; others were kept for 6 days, and did not begin to putrefy until the end of that period.

Observations. There is little doubt but that meat might thus be preserved for 8 years instead of 8 months: and if some economical plan on the same principle, could be put in practice on shipboard; the advantages would be incalculable. Before cooking such meat, the charcoal of course is to be washed, scraped, or rubbed off.

In an account of the voyage of the French discovery ship, which sailed from Bourdeaux in 1816, we find the following remarkable passage.

"In the route from the Sandwich Islands to Bourdeaux, the ship only touched at the port of Canton, and at the island of Mauritius. One fact appears truly singular, viz: that, of the flesh-meat substances embarked at Bourdeaux, in 1816, whatever returned, was in a state perfectly sound and well preserved ; this arose from making use of the process of M. Balguerie, which consists in placing the meat in three successive sprinklings of salt, and afterwards, in carbonised brine. Mutton dried in the oven, has been well kept in pulverised charcoal."

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* It will appear rather paradoxical to many readers to be told, that salt manufactured in England, and for which the natives pay 23 shillings a bushel, is, when transported across the Atlantic, sold so low as 2 shillings and six-pence, or half a dollar per bushel, in many of the cities of the United States of America: and this too, including all the expences of freight, land carriage, &c. The reason is, that for home consumption the English pay a duty of 17s. 6d. on every bushel they use. The duty on salt for agricultural purposes, has recently been greatly reduced.

DCCCCLVIII.

PRESERVATION OF ANIMAL FLESH FROM PUTREFACTION,

By Sulphurous Acid Gas.

A piece of fresh beef being introduced into a receiver filled with Sulphurous acid gas, quickly absorbed the whole of it. This was known by the filling up of the jar by the mercury, through which the meat was introduced. It soon lost its natural colour, and became like boiled meat. In the course of 76 days, it was harder and drier than roast meat, but had no smell of the Sulphurous acid. After leaving it 4 days in the open air, it did not putrefy, but became more compact.

DCCCCLIX.

ACTION OF AMMONIACAL GAS ON ANIMAL FOOD.

A piece of beef being introduced into a jar of Ammoniacal gas, assumed a fine red colour, which it preserved for 76 days. When withdrawn, it was soft, without smell, and had the colour and consistence of fresh meat. When exposed 4 days to the action of the Atmosphere, it did not putrefy, but lost its red colour, and became brown. It soon dried up, and was covered by a kind of *varnish.*

Observation. The vapour of ammonia is said to be a preventive against infection from typhous fever, &c.

DCCCCLX.

ENGLISH METHOD OF CURING HAMS, TONGUES, &c.

We here quote the same respectable authority, as in the curing of Meat by salting and the use of brine.—" For Pork and Mutton Hams, also for Hung-Beef, Tongues, &c. use the same proportion of Salt as before, but instead of half a pound, use a pound of Salt-petre. Put the Hams, &c. to soak all night in Salt and water, in order to extract the coagulated blood and other viscid juices still retained therein. Next day, rub them gently with the Salt and Salt-petre ; then place them in a tub, one upon another, till they are all salted; repeat the same every day for one week. By that time, they will have drawn a sufficiency of pickle to cover one half the number salted. Mix with this pickle (let us suppose drawn from twenty-four Hams) one quarter of a pound of Sal Ammoniac pounded very fine, and one pound of clean Muscovado sugar, well worked with a stick for a few minutes; in order to incorporate it with the pickle, pour it gently over the Hams and turn them every second day for fourteen days; at the expiration of which time, take them out, wash them, hang them up in a drying house, and keep them for one week drying without smoak. Then make a fire of oak timber, which must be covered three parts over with oak sawdust, mixed with Juniper Berries, and damped with water. In this state, keep them in the drying house from one to eight days. According to this method, and in the above mentioned proportions, I cure from two, to three hundred Hams, and great quantities of hung-beef and Tongues per week, during the season, and am happy to assert, that the goods so cured, give satisfaction both at home and abroad."

Observations. As hams, beef, and tongues, hung up only the time above mentioned, are not dry enough for use, they must then be hung up in a room moderately warm, and in a current of air; and when perfectly dry, pack them up in a box or cask in the following manner. A layer of hams and a layer of malt dust about three inches thick, till you have packed all. Let them remain in it; this will prevent the small *Hopper fly* during the summer season, and will, in the course of six weeks, produce a fermentation which will make the hams completely hot, so that the fat becomes transparent. As soon as this is found to be the case, take them out of the package, put them in bags, and hang them up for use; they will then have that flavour which is peculiar to the best hams.

Hams, and all other dry provisions, eat better after a voyage to the West Indies than they do here, merely on account of the fermentation they undergo by a long voyage. This fermentation extracts those superfluous particles of salt which they imbibe in the curing, makes the meat eat *shorter*, and gives it that flavour which many ham-eaters so much admire.

DCCCCLXI.

GERMAN MODE OF CURING HAMS.

In Westphalia, Hams are cured between November and March. The Germans pile them up in deep tubs, covering them with layers of Salt, Saltpetre, and a small quantity of Bay-leaves. In this situation they let them remain about four or five days, when they make a strong pickle of salt and water, with which they cover them completely; and at the expiration of three weeks they take them out of pickle, soak them twelve hours in clean well-water, and hang them up for three weeks longer in a smoke made from the *juniper* *bushes*, which in that country are met with in great quantities.

DCCCCLXII.

Roman Method of Curing Hams.

This mode is handed down to the moderns by M. Cato, in his treatise on Agriculture and farming, Chapter 162.

"When you have procured fresh Hocks, chop off the hoofs, take for each, half a bushel of *Romanian* salt,* bruise, and spread it at the bottom of the tub or cask; put in a Ham with the skinny side downwards, and cover it completely with Salt, then lay another upon it, and cover it in the same way. Take care that flesh do not touch flesh; cover all the Hams in the same manner, and when you have settled them properly in the vessel, spread Salt over all, so that no part of any of the Hams shall appear, smoothing the surface neatly. When they have been five days in pickle, take them out, brine and all; and replace them, (putting those at the bottom which before lay uppermost,) covering them and treating them as at first. At the end of twelve days, take out the Hams, wipe off the Salt, and hang them up in a current of air for the space of two days. On the third day, cleanse them thoroughly with a sponge, anoint them with Oil, hang them in the smoke two days, and on the third day take them down and rub them well with Oil and Vinegar mixed. You may then hang them up in your store room; neither maggots nor weevils will touch them."

Observation. It is to be observed here, that Cato's method is analogous to the use of Pyroligneous acid; for he prescribes *sponging the hams with vinegar and oil.* Now the acid in question is composed of vinegar, or acetic acid, and oil. What oil the Romans used for this purpose we do not know, but there can be little doubt, that if they even used olive or almond oil, it would soon be decomposed by the salted meat, and thus attain an empyreuma similar to that of the pyroligneous acid. The application of the oil could not be for any other purpose, than that of *flavouring* the meat, by its own decomposition.

DCCCCLXIII.

English Method of curing Bacon

The sides or flitches are to be laid in a wooden trough and sprinkled all over with bay salt; in which state they are left for twenty-four hours to drain away the blood, and the superfluous juices. After this they must be taken out, wiped very dry, and the drainings thrown away; next some fresh bay salt, well heated in a large iron frying-pan, is to be rubbed over the Meat, until it has absorbed a sufficiency of moisture; this friction is to be repeated four successive days, while the Meat is only to be turned every other day. If the flitches are large they should be kept in Brine for three weeks, and during this period, turned ten times, then taken out and thoroughly dried, either in the chimney corner, (as the practice is often in the country) in a bake-house, or in a drying-house, where a straw, or half-smothered wood, fire is kept up.

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* Doubtless, common salt.

Observation. To give bacon that agreeable flavour which distinguishes the produce of certain counties, the hair of the animal must not be scalded and scraped off, but must be burned or singed, by applying under it, a fire of straw just sufficient to remove the bristles.

DCCCCLXIV.

MODE OF CURING HADDOCKS, AS PRACTISED AT FINDON.

The village of Findon, in the county of Kincardine, Scotland has been long celebrated for the superior taste and flavour of its cured Haddocks. The adroitness of the operation, is no doubt one of the causes of this superiority, but as the inhabitants of this fishing village affirm that the turf they use for burning or smoking the fish, is by its nature, *peculiarly adapted to this operation*, we must conclude that unless a similar material be discovered near other fishing establishments, these villagers will still be able to maintain their monopoly; as the method of curing practised by them, is so well calculated to add to the sweetness and flavour of the Fish. The process is as follows:

When the boats return to the harbour, the Fish are carried home, and the women immediately proceed to open, wash, and split them, and they are *instantly salted*. They remain about fifteen minutes in the Salt, and are then hung up above a fire of turf to be smoked and dried. The greatest care and attention are bestowed as to cleanliness and the *immediate curing* of the Fish, which precedes every other employment, and is the peculiar duty of the women. In the corner of each house there is a place allotted for the particular purpose of smoking the Haddocks. Two horizontal poles project from the wall about six feet in length, four feet from the floor, and three feet asunder; the Haddocks are strung on small rods laid across these poles, and the turf is placed below and kindled, so that the smoke and heat ascending, they receive the full benefit of the combustion of the turf, and the process is completed in eight or ten hours. The Fish caught by mid-day are carried to the market of Aberdeen next morning, and are to be found in great perfection, on the breakfast-tables of the inhabitants of that city.

Observations. Findon haddocks are also sent to Edinburgh and London, for by drying them a little more than usual, they may be preserved for a considerable time; although they have not that delicious flavour, for which they are so much valued by those, who are accustomed to have them daily.

In the curing of red herrings, the fish, after being freed from the gut, are partially salted, and then suspended by the eye-holes on rods of wood, in a house constructed for the purpose; on the floor of which, fires of wood are lighted, and kept burning night and day with a smothered heat, until it is ascertained that the herrings are fully cured. If red herrings were as fully salted as those which are cured in the common manner for white herrings, the fish would be disagreeable from excess of salt, and would not possess the requisite flavour.

DCCCCLXV.

SUCCESSFUL METHOD OF CURING BUTTER,

As practised in Scotland.

It is well known, that Butter as it is generally cured, does not keep for any length of time, without spoiling or becoming rancid. The Butter with which the metropolis is supplied, may be seen at every Cheese-mongers, in the greatest *variety of quality and colour;* and it is too often the case, that even the *worst* butter, is compounded with better sorts, in order to procure a sale. These practices are detestable, and should be discountenanced by the legislature. Indeed no Butter should be permitted to be sold, but such as is of the best quality when fresh, and well cured when salted; as there is hardly any article more capable of exciting disgust than bad Butter.

But to obtain a reform in this matter, it is necessary to commence with the practices of the dairy; and the following process is recommended as the best at present known: Reduce separately to fine powder in a dry mortar, 2 pounds of the best, or whitest common Salt; 1 pound of Salt-petre; and 1 pound of Lump Sugar. Sift these ingredients, one above another on two sheets of paper joined together; and then mix them well with the hands, or with a spatula. Now preserve the whole in a covered jar placed in a dry situation. When required to be used, one ounce of this composition is to be proportioned to every pound of Butter, and the whole is to be well worked into the Mass. The Butter is to be packed in casks, &c. in the usual way.

Observations. . The above method is practised in many parts of Scotland: and is found to preserve the butter much better, than by using common salt alone. If butter made at one time be divided into two parts, and one be salted in the common way, whilst the mixture above mentioned is worked into the other, the difference in the quality of the two, will be found to be beyond all conception.

The butter cured with this mixture appears of a rich marrowy consistence and fine colour, and never acquires a brittle hardness, nor tastes salt; the other will be comparatively hard and brittle, approaching more nearly to the appearance of tallow, and is much salter to the taste. Butter cured by the above composition has been kept three years, and was as sweet as at first; but it must be noted, that butter thus cured requires to stand at least three weeks or a month before it is used. If it be sooner opened, the salts are not sufficiently blended with it, and sometimes the coolness of the nitre will then be perceived, which totally disappears afterwards.

One more observation on the preservation of butter is necessary. It is universally allowed that cleanliness is indispensible, but it is not generally suspected, that butter from being made in vessels or troughs lined with lead, or in glazed earthenware pans (which glaze is principally composed of Lead) is too apt to be contaminated by particles of that deleterious metal. If the butter is in the least degree rancid, this can hardly fail to take place, and it cannot be doubted, that during the decomposition of the salts, the glazing is acted on. It is better therefore, to use tinned vessels for mixing the preservative with the butter, and to pack it either in wooden vessels, or in jars of the Vauxhall ware, which, being vitrified throughout, do not require an inside glazing.

DCCCCLXVI.

MANUFACTURE OF PARMESAN CHEESE.

This Cheese has long been famous for its richness and flavour; the following mode of manufacture is described in the *Annales de Chimie.* The size of these Cheeses varies from 60 to 180lbs. according to the number of cows in each dairy. During the heat of summer, Cheese is made every day, but in the cooler months milk will keep longer, and the Cheese is made every other day. The summer cheese, which is the best, is made of the evening milk, after having been skimmed in the morning and at noon. Both kinds of milk are poured together into a cauldron capable of holding about 130 gallons, of the shape of an inverted bell, and suspended on the arm of a lever, so as to be moved off and on the fire at pleasure. In this cauldron the milk is gradually heated to the temperature of about 120 degrees; it is now removed from the fire, and kept quiet for five or six minutes. When all internal motion has ceased, the *rennet* is then added; this substance is composed of the stomach of a calf, fermented together with wheaten meal and salt; and the method of using it, is, to tie a piece of the size of a hazle nut in a rag, and steep it in the milk, squeezing it from time to time. In a short time, a sufficient quantity of rennet passes through the rag into the milk, which is now to be well stirred, and afterwards left to rest that it may coagulate. In about an hour the coagulation is complete, and then the milk is again put over the fire and raised to a temperature of about 145 degrees.

During all the time it is heating, the mass is briskly agitated, till the curd separates in small lumps; part of the whey is then taken out, and a small portion of saffron is added to the remainder, in order to colour it. When the curd is thus broken sufficiently small, nearly the whole of the whey is taken out and two pailfuls of cold water is poured in, the temperature is thus lowered, so as to enable the dairy-man to collect the curd, by passing a cloth beneath it, and gathering it up at the corners; the curd is now pressed into a frame of wood like a bushel without a bottom, placed on a solid table, and covered by a round piece.of wood, having a great stone or weight on the top. In the course of the night it cools, assumes a firm consistence, and parts with the whey; the next day one side is rubbed with salt, and the succeeding day the cheese is turned, and the other side then rubbed with salt in the same manner as before. This alternate salting of each side is practised for about forty days; after this period, the outer crust of the cheese is pared off, and the fresh surface is varnished with linseed oil. The convex sides are then coloured red with arnotto, and the cheese is fit for sale.

DCCCCLXVII.

PRESERVATION OF EGGS FROM PUTREFACTION.

To transport Eggs in a fresh state from one country to another, varnish, by dipping them in a solution of Gum-Arabic in water; and then imbed them in powdered Charcoal. The Gum Arabic answers the purpose of a varnish for eggs much better than any resinous gum, as it can be easily removed by washing in either warm or cold water; besides, it is much cheaper. Eggs preserved in this manner, will keep for many years, as the bed of Charcoal, from its porous nature, is a non-conductor of heat, and consequently maintains around the eggs an uniform temperature; preventing them from suffering by alternations of heat and cold, when they are removed from one climate to another.

Observation. This method is infinitely preferable to that of greasing them, for when the grease becomes rancid, it hastens or promotes putrefaction of the animal matter in the egg.

DCCCCLXVIII.

METHOD OF SALTING COD-FISH AT NEWFOUNDLAND.

Cod caught on the bank of Newfoundland is that which is known in Europe by the name of green or fresh cod; it is salted on board the ship as soon as caught.

The curing and salting of Cod requires a great deal of care. The following is the method generally practised.

As soon as the fisherman has caught a fish with his line, he pulls out the tongue, and gives the fish to another man called the beheader; this man, with a two-edged knife, slits the fish from the anus to the throat, which he cuts across to the bones of the neck. He then lays down his knife and pulls out the liver, which he drops into a kind of tray through a small hole, made on purpose, in the scaffold he works upon; then he guts it, and cuts off the head. This done, he delivers the fish to the next man, called the slicer, who takes hold of it by the left gill, rests its back against a board, a foot long, and two inches high, and pricks it with the slicing knife on the left side of the anus, which turns out the left gill. Then he cuts the ribs, or great bones, all along the vertebræ about half way down from the neck to the anus. He now does the same on the right side, and then cuts obliquely three joints of the vertebræ, through to the spinal marrow, dividing them too, and thus ends his operation.

A third helper then takes the fish, and with a kind of spatula, he scrapes all the blood that has remained along the vertebræ that were not cut; when the cod is thus thoroughly cleansed, (sometimes washed) he drops it into the hold, through a hole, made for that purpose, for the salter, who is ready to receive it.

The salter crams as much salt as he can, into the belly of the fish, lays it down, the tail end lowest, rubs the skin all over with salt, and even covers it with more salt. He then goes through the same process with the rest of the cod, which he heaps one upon another till the whole is laid up. The fish thus salted and piled up in the hold, is never meddled with any more, till it is brought home and unloaded for sale.

DCCCCLXIX.

METHOD OF DRYING COD AT NEWFOUNDLAND.

The manner of preparing and drying cod is as follows: The cod intended for drying, is caught and beheaded in the same manner as the other, but it is cut up differently. The slicer, instead of cutting the bones along the vertebræ only half way down from the throat to the anus, lays open the fish at one stroke quite to the tail all along the vertebræ, which he divides up to the throat; leaving each half of the vertebræ and the spinal marrow in the flesh of the cod.

When the slicer has thus dispatched a fish, he drops it into a sledge that holds about half a hundred weight, a boy then drives the sledge to the place where the salter salts and spreads the fish of the day. The salter lays down the fish flat with the flesh uppermost, and placing several of them side by side, he forms a layer of six, eight, twelve, or fifteen feet long, and three, four, or five broad: then he takes a large wooden shovel about two feet square, and sprinkles salt all over the layer of cod; taking care that the salt is laid on very even. When this layer is sufficiently salted, he spreads another over it, salts it in the same manner, and so on. When there are large, middling, and small cod, they are kept apart, for a different depth of salt is requisite for different sizes. Too much salt shrivels the fish and makes it brittle when it comes to dry, and too little makes it greasy and difficult to dry. The cod is left in salt two days at least, and sometimes about a fortnight, then it is washed. For this purpose they load it in hand barrows, and empty it out into a heap not unlike a great cage, by the sea side; there, they stir it about in sea water with paddles, to cleanse it from the salt and slime that it is imbued with, and when it is washed white they put it again on the barrows and carry it upon the gravel where it is to be spread. They first pile it up five or six feet high; the top of the heap terminates like a roof, that the fish may drain and harden; two, three, or four days afterwards, as the weather permits, they break up the pile and spread the fish upon the gravel, one by one, in rows, with the flesh uppermost. When it has lain thus in the morning sun, they turn it at about two in the afternoon, the skin uppermost; and in the evening, if they find that the wind and sun have dried them enough, they lay five or six of them one upon another, and a large one at the top to shelter them from the rain. The cod being thus disposed in little heaps, the skin upwards, they wait for the first fine day to spread them again on the gravel, first with the skin uppermost, and at noon they turn them. When they have been thus exposed, a second time, to the rays of the sun they are again heaped up, fifteen or twenty in a heap, and left till the next fine day, when they once more spread them on the gravel. If after this they find the fish thoroughly dry, they place the small ones in sharp round piles like pigeon houses, the middle sized in heaps of an hundred weight, and the large ones in smaller parcels. The former, when they have undergone a fourth sunning, that is, when they have been spread upon the gravel for the fourth time, are laid up in round piles; as to the large ones, they must be spread in the sun five or six times, at least, before they can be piled up like the others. When they have stood so for three or four days, the fishermen spread them all at once upon the gravel in the sun, and then proceed to a new pile; laying the largest fish for the groundwork, the middle sized next, and the smallest at top, because the larger they are, the greater pressure is requisite to squeeze out and throw off the moisture. This pile is left standing for a fortnight, and then the cod is again spread in the sun, after which the pile is erected once more, but reversed, so that what was at the bottom is now put at the top. This pile may be let alone for a month, after which the fish is once more exposed to the sun, and then piled up for the last time.

When all this is done, the fishermen make choice of a fine day to spread out the fish, only an arm full at a time, and lay them on the gravel; they examine them one by one, and lay apart those that retain any moisture; the dry ones are piled up, and the moist ones are dried again in the sun, and then put on the top of the other piles, that they may be at hand to be looked after, and dried again if they should want it. To conclude the whole process, just before they are shipped, they spread them by armsful upon the gravel, to air and dry them thoroughly.

In order to ship this Cod, they clean out the hold and lay a kind of floor, either of stone or wood, on which they place the fish, the first layer with the flesh uppermost, and all the rest with the skin uppermost. They do not fill the hold from one end to the other without interruption, but raise several piles both to keep the good and bad apart, and likewise to distinguish the different sizes of the fish. The large ones make the ground work of the cargo, the middle sized come next, and the small ones are laid at top; they line the bottom and sides of the hold with small twigs with the leaves on, but dried first for several days. The Cod being thus laid up in the hold, they cover it with sails, and never meddle with it more, until they unload it for sale in Europe.

Observation. Slitting, salting, and drying the cod, are three distinct operations, the last of which is sometimes very tedious and difficult. The sun is seldom seen at St. Pierre, and the want of sunshine occasions the loss of thousands of cod, which rot in the damps and fogs.

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DCCCCLXX.

CONVERSION OF ANIMAL-HIDES OR SKINS INTO LEATHER.

This process is what is generally termed *Tanning*. It is founded on the affinity which is known to exist between the gelatinous part of the Hide, and the *Tan* or astringent principle of Oak bark, and other vegetable substances.

It is well known that unless Hides are speedily dried, they become putrid, and consequently unfit for use. But even although they be successfully dried, they are still unfit for the manufacture of shoes and other necessary articles; being permeable to moisture, and liable to be soon destroyed by friction. Consequently, in almost every country where animal hides are used for purposes of convenience, they are made to undergo certain modes of treatment, which render them not only impermeable to water, but also tougher, and more pliable, so as to be easily and advantageously worked.

The combination of the Vegetable Astringent principle, or Tannin, with the gelatine (which forms almost the whole of the Hide,) changes it into Leather, which is a substance totally different in its properties to the Hide in the raw state. To tan a Hide then is to saturate it with Tannin.

Previous to the operation of Tanning, the raw or green Hides must undergo the process of washing and scouring, to free them from foreign matter, and to remove the hair. Hides are first put to steep in water, either pure or acidulated, to clear them of the blood and filth they may have collected in the slaughter-house. They are left to soak in the water for some time; and then *handled*, or trod upon by the feet, the better to cleanse them of all impurities. If the hides are dry, they are steeped a longer time, sometimes for four days, or longer, according to the season of the year, and care is taken to draw them out once a day, in order to stretch them on a wooden horse or beam. These two operations are repeated till the skin becomes raised or well softened. A running stream is necessary in these operations, else, the hides cannot fail of being ill prepared.

When the hides have been well raised, and softened, they are next freed from the hair, by the application of lime. In all tanneries, pits are formed having their sides lined with stone or brick, in which lime stone is slacked, so as to form *milk* of lime. Of these there are three kinds, according to the strength of the lime. The hides intended to be scoured are first put into the weakest of these pits, wherein they are allowed to remain, until the hair readily yields to the touch.

If this liquor be not sufficiently active, the hides are removed to the next in gradation, and the time they have for soaking is longer or shorter, in proportion to the strength of the lime, the temperature of the air, and the nature of the hides. Those of sheep require to remain in the pits only a few days. It has been proposed to substitute *lime water* in place of the milk of lime. But though the lime water acts at first with sufficient strength, its action is not sufficiently permanent, and in order to succeed in clearing the hides, it is necessary to renew it occasionally. In some tanneries, after the hides have been kept in the pits for a short time, they are piled up in a heap on the ground; in which state they are suffered to remain for eight days, after which they are returned into the same pits from whence they were taken, and this process is repeated till the hair can be easily scraped off.

Hides may also be cleansed, by subjecting them to an incipient fermentation, produced by souring a mixture of barley flour in warm water, and soaking the hides in it, till they are sufficiently swelled and softened to admit of being cleared from the hair. In each tan house are placed several tubs full of this acid liquor, which is of different strengths in proportion as it is soured. In those containing the weakest liquor, the hides are first soaked, handled, and washed; and after two, or at most, three of these operations, they are sufficiently prepared to admit of being freed from the hair. If more easily procured. Rye-flour may be substituted for barley.

The Calmuck Tartars employ sour Milk with the same view, and Pseiffer proposes the use of the Acid water obtained from the distillation of Coal and Turf. It indeed appears sufficiently ascertained, that all the vegetable Acids, and even diluted Sulphuric Acid, answer equally well for this purpose.

In some tanneries, they cleanse the Hides by throwing salt over the one-half of the skin, and doubling the other half over it; in proportion as each Hide is salted, they are laid one above another, and the whole are covered with straw or flax; fermentation soon begins, after which they are turned once or twice daily, until they are found to be in a proper state for removing the hair. They may be cleansed, however, much in the same manner, without the employment of Salt, by piling them up on a bed of litter, and covering them with the same material for twenty-four hours. At the end of this period they are turned over, and afterwards examined twice a day, in order to ascertain when the hair may be readily removed.

In some tanneries the hides are buried in dung, while in others, they are simply exposed in a close apartment, termed a *smoke house*, heated by means of a tan fire, which gives out smoke without flame. The hides are suspended on long poles placed across these apartments, which are heated very considerably.

All the methods in which fermentation is employed, are termed *heating processes*. In whatever manner this operation has been conducted, as soon as the hair is in a fit state to be removed, it is scraped off, on the wooden horse, by means of a blunt knife, or by a whet-stone. This operation is not only intended to remove the hair, but likewise the Scarf-skin or Epidermis, which is of a very different nature from that of the true skin. It is insoluble in Water, and Alcohol; is soluble in Acids, but not susceptible of combination with Tan, so that when left on the hide the Tan can only penetrate through the under side, by which means the process of Tanning is rendered extremely tedious.

There are many vegetable substances which possess the tanning principle, or Tannin; but those which possess most, are the Oak, Alder, Willow, and Peruvian Barks, also the Gallnut. The Peruvian Bark, from its scarcity and high price, is only used in Medicine. As Oak Bark possesses more Tan than any other vegetable substance, it is generally used for Tanning. This Bark, being stripped from those trees which are cut down in the Spring of the year, is dried in covered heaps, in the open air. It is then ground to a coarse powder in a mill, and mixed with water in the Tan-pits. The infusion, or liquor, which is of a brownish Amber colour, is called *ooze*; but is, properly speaking, a solution of Tannin and other vegetable matters.

The Hides, being scoured, raised, and softened, are first subjected to the action of weak *ooze* in one of these pits: here they remain for several weeks, and in the interim, are frequently agitated, or *handled*. From thence, it is removed to a pit containing a stronger infusion, where it remains for a considerable time; that is, until it has absorbed all the Tan. It is now immersed in a still stronger infusion, and so on. When the Hide has attained the colour of Cinnamon Bark on its outside, and when its internal parts are equally brown when cut through with a knife; it has received its full dose of Tan, and is converted into Leather. But if a white or greyish streak appear in the centre of the Hide or Skin, it is to be again immersed in the Tan-pit. Calf-skins require only about two or three months before the process of tanning is finished, whereas Ox-hides are not perfectly converted into Leather, for 6, 8 or even 15 months.

When perfectly tanned, the Hides are taken out, drained, passed between two Iron cylinders, that they may become pliant, and are then hung up in a drying house, until they become perfectly dry by exposure to the air. The smaller Hides now undergo the operation of *currying*, which renders them pliant, and reduces them to an uniform thickness. This consists in cutting, soaking, paring, scouring, stretching and oiling. The Leather is then blackened by a composition of lamp-black, oil, and tallow, which is rubbed hard into the fleshy side. It is now fit for sale.

Observations. It is to be observed that leather would be tanned much sooner, and equally well, if the tan-pits were made *within* a building, so as to be secured from rain: and if the building were furnished with flues or steam pipes, so as to keep the temperature of the vats constantly at a full summer heat. Another important improvement might be made in tanning, if the skins were hung vertically in the pits, so that the tanning liquor might, from the first part of the process, touch every part of the skin equally.

DCCCCLXXI.

METHOD OF TANNING LEATHER

By the Decoction of Bark, &c.

In 1804 a patent was granted for an improved method of tanning Hides: viz. by immersing them in the liquor in which Oak Bark had been boiled. According to this improvement, the Patentees filled a boiler of Copper (or any other metal that does not stain or colour the liquor) half full, with ground Bark, and poured water upon it, up to the brim. The whole is then boiled for three hours, till the tanning principle is completely extracted. The liquor is then suffered to run off by a cock into pits, where it stands to cool. The Hides are now put into the liquor, and *handled* frequently, by taking them out and putting them in again, because the liquor is too powerful for them to remain long at a time, in the first stages of tanning. They are then to be removed to fresh liquors, from time to time, as the old is weakened, until the operation is complete. By this method a greater quantity of the tanning principle is collected into a small compass; less Bark is consumed; and there is a great saving of labour.

If Leather is required with a whiter colour or bloom, a small quantity of the dust of Bark is mixed with the liquor. By this method, Hides that have been shaved in the baits may be better tanned in two or three weeks, and skins in ten or twelve days, than in the one case in nine months; and in the other in six months by the usual process.

Observations. Here, the great advantage is that derived from extracting the tanning principle, by means of boiling; as business to any extent may be carried on with about one-tenth part of the capital employed on the old plan.

Besides bark, the patentees make use of oak chips, and oak saw-dust; they have succeeded with the common heath or heather; and they find that the bark of most trees that produce *hard wood* has a tanning principle in them; but above all, they recommend the young shoots from the roots of oaks, and the superfluous twigs or branches that may be lopt off, so as not to injure the trees. These when cut in proper season, may be chopped and ground, and boiled with bark, and will produce a stronger tanning liquor than bark from the trunks of trees that have a thick rind, which cannot be separated from the bark.

By another patent in 1819, the art of tanning by decoction is still further improved. This patentee has proved that the trunk, roots, limbs, branches, and *leaves* of the oak, whether tree, pollard, coppice, or underwood, possess tanning properties in a sufficient quantity to be employed with advantage for tanning, by reducing them to chips or saw-dust, and then boiling and using them in the following way:

To tan calf, or other thin skins, put one hundred weight of the limbs or branches, chopped as above mentioned, into a copper containing about sixty gallons of water, and boil, till the water be reduced to from thirty-five to forty gallons; draw off the decoction.

Now add to the same limbs or branches forty gallons of water, and again boil till the water be reduced to about twenty-five gallons. The liquor thus produced by the second boiling is used as a weak ooze, in the first process of immersing the calf-skins, after they come from the scouring beam. The decoction first produced, is then to be used in the same way.

To tan *hides*, take one hundred weight of the limbs or branches, three-quarters of a hundred weight of oak saw-dust, (the sooner the latter is used after being made the better), and one-quarter of a hundred weight of the root, boil in eighty gallons of water, till reduced to from fifty to sixty gallons. Draw off the decoction, and put it aside for use. To the materials left in the copper add sixty gallons of water, and again boil, till reduced to from thirty to thirty-five gallons. The liquor produced by this second boiling is to be employed in the first stage of tanning hides after they come from the beam; and afterwards the decoction first produced is to be employed. The skins and hides having undergone the before-mentioned processes, add as much oak-bark or tan-liquor, or both, to the respective decoctions, as is necessary to complete the tanning. The quantity of each will vary according to the strength of such decoctions; which strength will depend on the age and size of the tree, and other circumstances.

DCCCCLXXII.

CONVERSION OF SHEEP-SKINS INTO LEATHER.

Sheep-skins which are used for a variety of purposes, such as, Gloves, Book-covers, &c. and which when dyed, are converted into mock-Morocco Leather, are dressed as follows:—They are first to be soaked in water and *handled*, to separate all impurities, which may be scraped off by a blunt knife on a beam. They are then to be hung up in a close warm room to putrefy. This putrefaction loosens the Wool, and causes the exudation of an oily and slimy matter, all which are to be removed by the knife. The Skins are now to be steeped in *Milk of Lime*, to harden and thicken; here they remain for a month or six weeks, according to circumstances, and when taken out, they are to be smoothed on the fleshy side by a sharp knife. They are now to be steeped in a bath of bran and water, where they undergo a partial fermentation, and become thinner in their substance.

The Skins, which are now called *Pelts* are to be immersed in a solution of Alum and common Salt in water; in the proportion of 120 Skins to 3 pounds of Alum and 5 pounds of Salt. They are to be much agitated in this compound saline bath, in order to become firm and tough. From this bath they are to be removed to another, composed of bran and water, where they remain until quite pliant by a slight fermentation. To give their upper surfaces a gloss, they are to be trodden in a wooden tub, with a solution of yolks of eggs in water, previously well beaten up. When this solution has become transparent, it is a proof that the skins have absorbed the glazing matter. The pelt may now be said to be converted into Leather, which is to be drained from moisture, hung upon hooks in a warm apartment to dry, and smoothed over with warm hand-irons.

Observations. To prepare sheep leather for various elegant purposes, by dying; the skins, after been taken from the lime-bath, are to be immersed in another, composed of dog and pigeon dung dissolved by agitation in water: here they remain until the lime is separated, and until the skins have attained the state of *soft pliable pelt.* To dye this pelt *red*, the skins are to be washed and sewed into bags, and stuffed with clippings and shavings of leather, or any other convenient substance, and immersed with the *grain side outwards* in a bath of alum and cochineal of the temperature of 170° or 180° Fahr. where they are to be agitated until they are sufficiently dyed. Each bag is now to be transferred to a *sumach* bath, where they receive consistency and tenacity. From this bath it is customary to remove the skins, and to plunge them into a saffron one, to improve their colour.

To dye these skins *black*, the washed pelt is to be first immersed in the sumach bath, and then to be rubbed over on the grained side, by a stiff brush dipped in a solution of acetate, or pyrolignite of iron.

To give these skins the grain and polish of Morocco leather, they are first oiled, and then rubbed on a firm board by a convex piece of solid glass, to which a handle is attached. The leather being now rendered more compact, is rubbed or pressed hard, by a sharply grooved boxwood instrument, shaped like the glass one just described.

Lamb and kid skins are dressed, tanned, and dyed in a similar manner.

DCCCCLXXIII.

MANUFACTURE OF REAL MOROCCO LEATHER.

Goat skins are to be cleansed, have their hair removed, and to be limed as in the before mentioned processes. They are then to undergo a partial fermentation by a bath of bran and water, and afterwards to be immersed in another bath of *white figs and water*, where they are to remain for five or six days. It is now necessary to dip them in a solution of salt and water, to fit them for dyeing. To communicate a *red* colour, the Alum and Cochineal Bath is to be used as for sheep-skins; for *black*, Sumach, and Iron liquor as before; and for *yellow*, the bath is to be composed of Alum and the pomegranate bark.

The Tanning, dressing, and graining are the same as for sheep skins.

DCCCCLXXIV.

MANUFACTURE OF RUSSSIA LEATHER.

Calf-skins being steeped in a weak bath of Carbonate of Potass and water, are well cleaned and scraped, to have the hair &c. removed. They are now immersed in another bath, containing dog and pigeons dung in water. Being thus freed from the Alkali, they are thrown into a mixture of Oatmeal and water, to undergo a slight fermentation. To tan these hides, it is necessary to use Birch bark instead of Oak bark; and during the operation they are to be frequently handled or agitated. When tanned, and perfectly dry, they are made pliable by Oil and much friction; they are then to be rubbed over gently with *Birch Tar*, which gives them that agreeable odour, peculiar to this kind ot Leather, and which secures them against the attacks of moths and worms. This odour, the leather will preserve for many years; and on account of it, Russia Leather is much used in binding handsome and costly books. The marks, or intersecting lines on this Leather, are given to it by passing over its grained surface, a heavy iron cylinder, bound round by wires.

Observations. To dye this leather of a *black* colour, it is to be rubbed over, after tanning, with a solution of acetate, or pyrolignite of iron: to dye it *red*, alum and Brazil wood are used. At Astrakhan, in Tartary, another kind of leather, both beautiful and durable, is manufactured from deer and goat skins. They are cleaned and dressed in the same manner as sheep skins, and then put into a bath of bran in a state of fermentation with water, for three days. Each skin is then put into a wooden tray, where being spread out, it receives a portion of a liquor composed of Honey and water. When the skin has combined with this liquid, it is immersed in very salt brine for a short time, and is then dried. To dye it *red*, it is to be made up in bags, and dipped in a bath of cochineal water, and an alkaline plant found in the deserts; it is now to be immersed in a solution of Alum, and then tanned with sumach. To give this leather a brilliant and more *lasting red*, it is dipped in an infusion or decoction of galls, instead of sumach. When to be dyed *yellow*, the berries of buckthorn, or the flowers of wild camomile are used. The graining of this leather is given by an iron instrument of great weight, having a number of blunt points.

DCCCCLXXV.

METHOD OF TANNING FISH AND OTHER NETS.

The following method was invented by a ship-builder at

Bridport. He puts one hundred weight of oak-branches and one hundred weight of spent bark from any tannery, into one hundred gallons of water, and so in proportion, for a greater or less quantity. After boiling the same till it be reduced to about eighty gallons, he takes the branches and spent bark from the copper, by means of any convenient instrument, and then immerses as many nets, sails, or other articles, as are required, into the liquor left in the copper; taking care, that they are completely covered. He boils the whole together for about three hours, then removes the fire, and suffers the liquor to get cool: after which he removes the nets, sails, or other articles, from the furnace, and hangs them up to dry.

DCCCCLXXVI.

To PURIFY SICK ROOMS, &c.

From noxious Vapours, Exhalations, and all Kinds of infected Air.

Put half an ounce of finely pulverized black Oxide of Manganese into a saucer, and pour over it nearly an ounce of Muriatic Acid: place the saucer on the floor of the infected apartment, then go out and shut the door. Abundance of Chlorine Gas will now be disengaged, which combining with the infected air, will completely neutralize it; and thus the contagion will be completely destroyed.

Observations. In this useful experiment, the muriatic acid, in attacking the oxide of manganese, loses its hydrogen, and is thus converted into chlorine. The hydrogen combines with some of the oxygen of the oxide, and these two substances are converted into water.

Muriatic acid with red oxide of lead will have a similar effect. Sulphur burnt with a similar intention, has thus been converted into sulphurous acid gas, which has the power of overcoming the effects of noxious vapours: but in many respects the use of chlorine is preferable. Lime water has a very powerful effect in absorbing carbonic acid gas, and no doubt, shallow vessels filled with it, might be of great use in absorbing it, in workshops, &c where charcoal is burnt.[*] Newly prepared charcoal has the power of absorbing various kinds of noxious gases, and might be used with considerable advantage for the purification of privies, if small pieces of it are strewed upon the floor. The gases will be condensed in the cells of the charcoal.

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[*] It is to be feared that the deleterious effects of this gas are but too much felt by workmen who are obliged, on account of the nature of their trades, to burn charcoal.

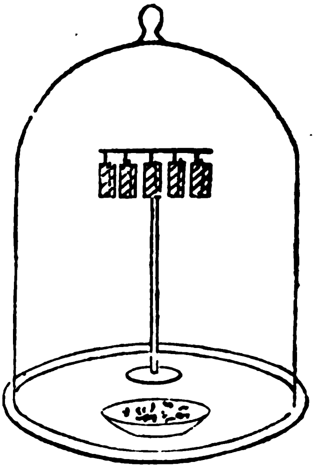
DCCCCLXXVII.

Mode of Disinfecting Substances

Infected by the Plague or other contagious Diseases.

Chlorine has been successfully used for this purpose in some parts of Spain.

Expose 4 ounces of meat in a saucer, until it becomes nearly putrid: suspend bits of paper, fur, feathers, cotton, silk and wool, upon hooks fixed in an horizontal piece of wood attached to a perpendicular one, which is supported by a pedestal of lead: cover the whole with a bell glass fixed in the rim of a piece of wood on which the saucer is placed. The edges of the rim should be puttied. Fix a cork very tight in the top aperture of the bell glass, and let the whole rest in a warm room for a fortnight. On withdrawing the cork, the degree of putrefaction may be easily ascertained. When sufficiently impregnated, let each substance be taken out in succession, and enveloped in a sheet of paper folded like a letter: and suspended on a hook in another bell glass, under which materials for producing Chlorine are placed in a saucer, or cup. These materials are Muriatic Acid poured over red Oxide of Lead, or pulverized Oxide of Manganese. In a short time the putrid odour will be dispersed, and the papers, which are intended to imitate letters supposed to be infected, will smell only of Chlorine.



Observation. Each letter should have three or four parallel incisions made in it with a sharp knife, to admit the disenfecting gas more readily. Above is a figure of the apparatus.

DCCCCLXXVIII.

Simple Method of preserving Fruit.

The following simple method of effecting this desirable object was first successfuly practised by Mr. Saddington.

The fruit, being picked clean, and not too ripe, is to be put into common bottles, which must be filled quite full. These bottles, having corks stuck lightly in them, are to be placed upright in a pan of Water, which is to be heated gradually to 160° or 170° Fahrenheit; or until the water feels hot to the finger, but not so hot as to scald. This degree of heat is to be kept up for half an hour, and then the bottles being taken out, one by one, they are to be filled up to within an inch of the cork with *boiling* water, the cork fitted very close and tight, and the bottle laid on its side that the cork may be kept moist. To prevent fermentation and mould, the bottles are to be turned once or twice a week for the first month or two, and once or twice a month, afterwards.

Observations. Fruit treated in this way, will keep for two years or more. When used, some of the liquor first poured off, serves to put into pies, &c instead of water, and the remainder being boiled up with a little sugar, will make a rich and agreeable syrup.

The fruit ought not to be cracked by the heat. Some trials were made by keeping the bottles in a heat of 190° for three quarters of an hour, but the fruit was reduced to nearly a pulp.

Samples of apricots, gooseberries, currants, raspberries, cherries, plumbs, Orlean-plumbs, egg plumbs, damsons, Siberian crabs, green gages, and rhubarb, in great perfection, were presented to the Society of Arts by Mr. Saddington. In the summer of 1807, it cost about 1*l.* 9*s.* exclusive of the charge of bottles and corks, to preserve 95 bottles of fruit, which were worth in the winter at least one shilling each; so that there was a clear gain of 200 per cent.

DCCCCLXXIX.

PRESERVATION OF FRUIT IN CARBONIC ACID GAS.

This important discovery was made by M. Dumont. He placed various kinds of ripe fruit in glass vessels, filled with Carbonic Acid Gas, obtained from Carbonate of Lime by Sulphuric Acid, and neither the colour nor taste of the Cherries was altered at the end of fifteen days; at the end of six weeks, they were in the same state, and had a peculiar but pleasant odour as if they had been preserved in brandy.

DCCCCLXXX.

PRESERVATION OF GRAPES.

In a cask or barrel, having its crevices well closed to prevent access of the external air, place a layer of bran, which has been well dried in an oven; upon this place a layer of bunches of Grapes, well cleaned, and gathered in the afternoon of a dry day, before they are perfectly ripe; proceed then with alternate layers of bran and Grapes till the barrel is full, taking care that the Grapes do not touch each other, and to let the last layer be of bran; then close the barrel so that the air may not be able to penetrate. Grapes thus packed will keep for a twelvemonth. To restore their freshness, cut the end of each bunch and put that of white Grapes into white wine, and that of black Grapes into red wine, as flowers are put into water to keep them fresh.

Observations. It is customary in France to pack grapes for the London markets in *saw-dust.* If the precaution of drying the saw-dust by a gentle heat, before use, be had recourse to, this expedient may answer very well; but if this is not done, and if the wood has been cut fresh, the turpentine, and other odours of the wood cannot fail to injure the fruit. Oak saw dust will answer best.

DCCCCLXXXI.

Preservation of Flowers, for Distillation.

Rub three pounds of Rose-leaves for two or three minutes with a pound of common Salt. The flowers being bruised by the friction of the grains of Salt, form a paste which is to be put into an earthen jar, or into a water-tight barrel. The same process is to be repeated until the vessel is filled, so that all the Roses may be equally salted. The vessel is then to be shut up and kept in a cool place until wanted.

For distillation, this aromatic paste is, at any season, to be put into the body of the still with twice its weight of Water; and when heat is applied, the Oil, or essential Water is to be obtained in the common way. Both the Oil and Water, are in this way produced in greater quantity, than by using the leaves without the Salt: besides, the preserved paste will keep its flavour and strength unimpaired for several years.

Observations. Other flowers capable of affording essential oils may also be treated in the above mentioned way, with economy and advantage; as there is thereby no occasion to carry on a hurried process in the heat of summer, when these are in perfection.

It appears, that in general, the usefulness of applying common salt to preserve those vegetables which are brought from a distance for the use of apothecaries or perfumers, has not been sufficiently appreciated. A French chemist, M. Rouelle perfumed his laboratory during the whole of his course of chemistry, in the winter of 1775, by distilling the roses he had salted in the June preceding.

DCCCCLXXXII.

To recover Hay and Corn from Mildew, &c.

The late Arthur Young discovered, that Hay damaged by rain and dampness, may be recovered by the use of common Salt. The Salt is to be used in the proportion of one peck to a load of Hay, and is to be strewed upon the Hay, in layers, as it is re-packed from the putrid stack. This mode of treatment will have a great effect in sweetening and freshening the Hay, however bad it may be, even though it be quite *black*; and it has been repeatedly proved, that Horses and horned Cattle will greedily eat *damaged Hay salted*, which without this addition, they will not touch.

Observations. Dr. Cartwright discovered that a solution of common salt, sprinkled on corn affected with mildew, completely removes the disease. In the year 1818, he was engaged in a series of experiments to ascertain the *minimum* of salt that would be required to destroy vegetation in certain weeds, as coltsfoot, bindweed, the common thistle, &c. The salt, it was found, had very little effect on weeds or other vegetables when they had arrived at that stage in which they cease to be succulent, and are becoming fibrous; but as soon as the rain washed the salt down to their roots, (if in sufficient quantity,) they languished and died. Happening to have some wheat at the time, that was mildewed, he reasoned thus: "The mildew is known to be a fungus, whose roots being in the straw of the corn, cannot, therefore, be very deep; if I sprinkle the corn with a solution of salt, why should not the fungi languish and die, as well as weeds when properly dosed at their roots with salt?" The experiment was tried, and the result such as was anticipated, and without any injury to the wheat; salt having no injurious effect on fibrous matter, whether vegetable or animal. The expence in this case ceases to be an object; for six or eight bushels will serve on an acre, which, at the price of salt applied to agriculture, will be under twenty shillings; and this will be more than repaid by the improvement of the manure arising from the salted straw. Two men, one to spread, and the other to supply him with the salt water, will get over four acres in a day. The operation of the remedy is very quick: in less than eight and forty hours, even the vestiges of the disease are hardly discernible. Its efficacy has been completely verified by more recent experiments.

DCCCCLXXXIII.

Purification of Rape Oil.

The following simple method of rendering Rape Oil equal to Spermaceti Oil for the purpose of illumination, was first practised by Mr. Edward Roche, of Cork, who thus describes the discovery:—"I thought I should render the public very great service, could I, by some mode, render any of the cheap Oils of our country effectual for the service of the Argand-lamp. Many persons in England told me, that our Oils were of too gelatinous and viscous a nature to be drawn up in the capillary tubes of the cotton wick. I therefore perceived, the first thing I had to effect was, to deprive them, as much as possible, of those two bad qualities. I entered into a variety of Experiments, some of them long and tedious, which I shall not take up time by enumerating.

"I began by washing the Oil with spring-water: which is effected by agitating the Oil violently, with a sixth part of the Water. This separates the particles of the Oil, and mixes those of the Water intimately with them. After this operation, it looks like the yolks of eggs beat up.—In less than forty-eight hours they separate completely, the Oil swimming at top, the water with all feculent and extraneous particles subsiding to the bottom. I improved very much on this, by substituting sea Water in the place of fresh Water. I tried whether fresh Water impregnated with Salt, might not do as well as sea Water; but found the light not so bright, and of a reddish east. The Oil which I have washed is rape Oil, for which I am charged 4*s.* 4*d.* a gallon. I have now made use of it constantly for two months: it gives no bad smell, and when burning close to the Spermaceti Oil is not to be distinguished.

"By the process of washing, the Oil does not lose one hundredth part. The Experiment can at all times be made in a glass decanter. I purpose making it in a churn, with a cock at the bottom, the Water to come up very near to the cock, by which all the Oil can be drawn off, after it has deposited its impurities."

DCCCCLXXXIV.

PREPARATION OF SAUR-KRAUT.

Every Russian family, from that of the boor to the nobleman, lays in its stock of cabbage to make Saur-Kraut, about the month of October, before the setting in of the winter frost. It is prepared in the following manner:—They take a large strong wooden vessel, or cask, with which every family is furnished, resembling the salt-beef cask of the Scotch farmers, and capable of containing as much as is sufficient for the winter's consumption of the family. They then gradually break down or chop the cabbage, (deprived entirely of the loose outside green leaves,) into very small pieces, beginning with one or two cabbages at the bottom of the cask, and adding others at intervals, pressing and rubbing them by means of a wooden spade, against the sides of the cask, until the vessel is nearly full. They then place a heavy weight upon the top of it, and allow it to stand near to the peach stove, or any other warm place, for four or five days. By this time it will have undergone fermentation, and be ready for use. Whilst the cabbage is passing through the process of fermentation, a very disagreeably fetid, acid smell is exhaled from it; and this is strongly perceptible to the olfactory nerves of a person passing near the house, in which the preparation of the Saur-Kraut is going on. They now remove the cask to a cool situation, and keep it always covered up. Aniseeds, which are strewed among the layers of the cabbage during its preparation, communicate a peculiar flavour to the Saur-Kraut at an after period.

In the boiling of the Saur-Kraut, and preparation of it for the table, two hours are the least period which they allow it to be on the fire. It forms an excellent, nutritious, and antiscorbutic food for winter use. For the greater part of the year, this article, in one form or another, supplies a daily dish to the table of the Russian peasant. It may be made use of as a separate dish by itself, made into soup, or it may be eaten with boiled animal food.

DCCCCLXXXV.

Method of Preserving Yeast.

Set a quantity of strong beer or whisky barm (Yeast) to settle, closely covered, that the spirit may not evaporate. In the mean time have ready as many small hair sieves as will hold the thick barm; small vessels are mentioned, because, dividing the Yeast into small quantities, conduces to its preservation. Lay over each sieve a piece of coarse flannel, that may reach the bottom, and leave at least eight inches over the rim. Pour off the thin liquor, and set it to subside, as the grounds will do for immediate baking or brewing if covered up a few hours. Fill the sieves with the thick barm, and cover them up for two hours: then gather the flannel edges as a bag, and tie them firmly with twine. Lay each bag upon several folds of coarse linen, changing these folds every half hour, till they imbibe no more moisture; then cover each bag with another piece of flannel, changing it if it becomes damp, and hang them in a cool airy place.

Observations. Remember that the yeast should be strained before it is put to settle, and that while the flannel bags are laid upon the folds of linen, they must be covered with a thick cloth. When the yeast is wanted for use, prepare a strong infusion of malt, to a gallon of which add a piece of dried barm, about the size of a goose's egg; indeed, the proportion must depend on its quality, which experience only can ascertain. The malt infusion must be almost milk-warm when the yeast is crumbled into it: for two hours it will froth high, and bake two bushels of flour into well-fermented bread. A decoction of green pease, or of ripened dry pease, with as much sugar as will sweeten it, makes fairer bread than the malt infusion; but it will take a larger quantity of dried yeast to produce fermentation.

It was customary, some years ago, to reduce porter yeast to dryness, and in that state, it was carried to the West Indies, where it was brought by means of water to its original state, and then employed as a ferment.

DCCCCLXXXVI.

To RESTORE AND IMPROVE MUSTY FLOUR.

This very important discovery was made by E. Davy, Esq. of the Cork Institution. He found that the Carbonate of Magnessia in small quantity, had the property of restoring to its primitive state, Flour which has a musty smell and taste from dampness and other causes.

One pound of the Carbonate of Magnessia is to be well combined with two hundred and fifty pounds of Musty Flour; that is, in the minor proportion of thirty grains of the Carbonate, to one pound of flour. It is to be leavened and baked in the usual way of making Bread. The loaves will be found to rise well in the oven, to be more light and spongy, and also whiter than bread in the common way. It will likewise have an excellent taste and will keep well.

Observation. The use of magnesia in bread making is well worthy the attention of the public: for if it improves *musty* flour, how much must it improve bread in general?—As to bakers, they may be deterred from its use by the general legislative prohibition of drugs in bread-making; but farmers, and families in the country, who make their own bread, will no doubt be glad to adopt so cheap a process of improving their flour as the above. The use of magnesia in bread, independent of its improving qualities, is as much superior to that of alum as one substance can be to another.

DCCCCLXXXVII.

METHODS FOR PREVENTING THE DECAY OF WOOD.

The following is extracted from a paper read by Dr. Parry of Bath before the Society of Arts.

It appears that the contact of Water and Air are the chief causes of the decay of Wood. If, therefore, any means can be devised, by which the access of moisture and Air can be prevented, the Wood is so far secure against decay. This principle may be illustrated by supposing a cylinder of dry Wood to be placed in a glass tube or case, which it exactly fills, and the two ends of which are, as it is called, hermetically sealed, or entirely closed. Who will doubt that such a piece of Wood might remain in the open

Air a thousand years unchanged? Or let us take a still more apposite illustration of this fact; that of Amber, a native Bitumen, or Resin, in which a variety of small flies, filaments of vegetables, and others of the most fragile substances, are seen imbedded, having been preserved from decay much longer probably than a thousand years, and with no apparent tendency to change for ten times that period.

To exclude air and moisture, various expedients have been employed, of which the most common is covering the surface with paint; which is Oil mixed with some substance capable of giving it the colour which we desire. It is well known that several of the Oils, as those of Linseed, Hempseed, &c. become dry when thinly spread on any hard substance. The drying quality is much assisted by being previously boiled with certain metallic Oxides, more especially that of Lead, or Litharge. The crust so formed is with difficulty penetrated by moisture or air. For this purpose also, drying Oil is spread on Silk or Linen, in the manufacfure of Umbrellas, &c.

When Paint is employed within doors, it is customary to add to the Oil, besides the colouring matter, some essential Oil of Turpentine, which not only makes it dry more readily, but, by giving it greater tenuity, causes it to flow, more freely from the brush, and therefore to go farther in the work. For the same purposes it forms a part of the Paint used on Wood and Iron work in the open air; but, most improperly: for on rubbing Wood painted white, and long exposed to the weather, the white-lead comes off in a dry powder like whiting; as if the vehicle which glued it to the Wood had been decomposed and lost, leaving only the pigment behind.

The composition, which experience has proved to be the best adapted for the preservation of Wood from both species of decay, (viz. the wet and dry rot) is as follows: Melt 12 ounces of Rosin in an iron pot or kettle: when melted, add 8 ounces of roll-brimstone, and just when both are in a liquid state, pour in 3 gallons of train, or whale Oil. Heat the whole slowly, gradually adding 4 ounces of Bees-wax cut into small bits, frequently stir the mixture, and as soon as the solid ingredients are dissolved, add as much Spanish brown, or red or yellow Ochre, or any other colour (first ground fine with some of the Oil) as will give the whole a deep shade. It will now be fit for use.—Lay on this Paint or Varnish as hot and thin as possible; and some days after the first coat becomes dry, give a second. These coats will preserve planks, &c. for ages. What remains unused, will become solid on cooling, and may be remelted for future occasions. Dr. Parry used some of this composition on Elm-paling; which, 18 years after, was as sound as when first put up.

Observations. All the substances contained in this mixture are capable of perfect incorporation with each each other by heat, and when separately exposed, are with great difficulty acted on by water or air in any heat which occurs in our climate. They should be applied hot with a common painter's brush on the wood which is previously very dry, so as to sinkly deeply into its pores; and though at first they are apparently somewhat greasy when cold, yet after some days they make a firm varnish, which does not come off on rubbing. When it is required to give beauty to the work, colouring matters may either be added to the mixture, or afterwards applied over it in form of common paint. Two coats of the composition should always be given; and in all compound machinery, the separate parts should be so varnished, before they are put together; after which it will be prudent to give a third coating to the joints, or to any other part which is peculiarly exposed to the action of moisture, such as water-shoots, flood-gates, the beds of carts, the tops of posts and rails, and all timber which is near or within the ground. Each coat should be dry before the parts are joined, or the last coat applied.

This composition will also prevent iron and other metals from rusting.

It is necessary to mention, that compositions made of hot oil should for the sake of security be heated in metallic or glazed earthen vessels, in the open air. For, whenever oil is brought to the boiling point, or 612° of Fahrenheit's thermometer, the vapour immediately catches fire, although not in contact with any flame: now though a lower degree of temperature than that of boiling, should be used in this process, it is not always practicable either exactly to regulate the heat, or to prevent the overflowing of the materials: in either of these cases, were the melting performed in a house, the most fatal accidents might follow.

When wood decays *under cover*, that condition is usually called the dry-rot.

It affects the interior doors, shelves, laths, boards which subdivide the layers of wine, and all other wood work in certain cellars; beams and rafters which support the roofs of close passages; joints lying on or near the earth; the wainscoting of large rooms, little inhabited, in old and especially single houses; and wood in various other situations of a similar kind, which need not be particularized. In some of these cases, while one sample or portion of wood shall suffer the dry rot, another specimen or portion shall remain unchanged. In other instances, wood of various kinds and qualities has been successively employed, and all has alike suffered. During the stages of change, a crop of *mucor* or mould, and very frequently of fungi, has sprung from the porous mass; and the decay is always attended by a wide-spreading exhalation, the odour of which cannot well be described, but which is sufficiently known.

What then are the causes of this destruction? Precisely the same as those before described; though their action is differently modified, and less obvious to observation. The decay is produced by the putrefactive fermentation of the component parts of the wood in connection with moisture, without which wood cannot putrefy. The term dry-rot is, therefore, so far from being expressive of the real fact, that decay proceeds under these circumstances more quickly than in the open air, precisely because the wood is more constantly and uniformly wet: just as the lower parts of posts and rails, and any cavities in timber exposed to the weather, rot sooner than those parts which readily and speedily dry.

The smell which we perceive on going into vaults or cellars where this process is going on, arises partly from the extrication of certain gases, mingled perhaps with some volatile oil; and partly from the effluvia of those vegetable substances, which have already been said to grow on it; and which, though they begin merely because the decayed wood is their proper soil, yet afterwards, tend probably to the more speedy decomposition of the wood itself. They cannot, however, with more propriety be said to be the cause of the dry-rot, than the white clover, which appears on certain lands after a top-dressing of coal-ashes, can be said to have produced the soil on which it flourished.

The dry-rot, then, is a more or less rapid decomposition of the substance of the wood, from moisture deposited on it by condensation; to the action of which moisture, it is more liable in certain situations, than in others. This moisture, too, operates more quickly on wood which most abounds with *the saccharine or fermentible principles of the sap.*

To prevent this decomposition, the first point is to choose timber properly felled,* and well dried.

Next, where it is practicable, a current of air should be frequently made to pass along the surface of the wood. This expedient seems to have been particularly attended to by the ingenious architects of our Gothic churches, who are said *with that view* to have left various openings in the walls between the two roofs of those edifices. In order also to promote evaporation, a certain degree of heat, such as that of air heated by the sun or fire, should if possible, be from time to time applied. Cellars themselves ought to have some communication with the outward air by means of windows and shutters, or trap-doors: and these may be for a short time opened in proper weather, so as to have a draught of air. Besides, that a very low degree of temperature is not necessary for the preservation of fermented liquors, (provided that temperature be *uniform,*) is evident from the practicability of keeping wine extremely well, in cellars which are not damp.

Lastly, the dry-rot may in all cases be infallibly prevented, where it is practicable to cover the surface of the wood, (properly dried,) with a varnish which is impenetrable and indestructible by water. With this view, *two or three coats of the composition before described* should be laid on the dry wood, before it is erected or put together, and a third or fourth after it is put in its place; and proper means should be taken, thoroughly to dry each successive coat of varnish. In situations of this kind, what means of preservation are necessary must be employed

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* It has been asserted, that if an oak, or any other tree, which is stripped of its bark, be suffered to stand two or three years before it is felled, the wood will have acquired a very great degree of strength and durability.

at first; as it seems scarcely possible to renew them on fixed timber, with any chance of benefit.*

Wood is often destroyed by insects and worms, and various methods have been tried to remove them, but without effect. One of the best methods that have been in use, was smearing the wood over with oil of turpentine; but this, from its volatile nature, requires a frequent renewal.

It appears that most insects are fond of sugar and mucilage; which is the probable reason, why that wood is most subject to be penetrated by worms, *which is felled when it most abounds with sap.* In such cases, it might be well to try the effects of washing the wood, (previously to the use of the varnish,) with a solution of arsenic in hot water; in the proportion of 1lb. to 10 gallons; or with a strong decoction of coloquintida or bitter apple, or white hellebore; after which the wood must be completely dried before the application of the varnish in the manner before directed. All these preparations are extremely cheap, and are either destructive or offensive to insects, and therefore will probably be an effectual defence against any injury from that cause.

DCCCCLXXXVIII.

PRESERVATION OF WOOD BY CHARCOAL.

The following mode of preventing rottenness in Pales, Water-shoots, &c. is recommended by Dr. Parry who paid much attention to this important subject. He says:

"More than 30 years ago this subject presented itself to my mind, on seeing some Water-shoots which had been pitched and painted in the common way, taken down in a state of complete rottenness. I had read that Charcoal buried in the moist earth, had come down to us perfectly sound from the times of the Romans; and that posts long withstood the same moisture, if the part intended to be put into the ground was charred all round to a certain depth. Impressed with these facts, I determined to try an artificial coat of Charcoal, and when new Water-shoots were constructed, I strongly and carefully rubbed them with a coat of drying oil, which I immediately dredged all over with a thick layer of *Charcoal* finely powdered, and contained in a muslin bag. After two or three days, when the Oil was thoroughly dried, and firmly retained the greatest part of the Charcoal, I brushed off what was loose, and over that which adhered, I applied a coat of common lead coloured paint, and a few days after, a second. The whole became a firm and solid crust; after which the shoots were put in their places, and being examined many years afterwards, appeared perfectly sound."

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* It is said that an American ship lately at Cowes, (built with spruce and white oak, sixteen years ago,) has all her original timbers and planks in the most perfect state of preservation; owing to having been, while on the stocks, filled up between the timbers with salt, and whenever she has been opened for examination, filled up again.

Observations. Any other colour would probably have succeeded equally well with that which I employed. I do not think that lamp black, which is a pure species of charcoal, would have answered the purpose of forming a thick defensive covering so well as the grosser charcoal which I used. But whatever sort of charcoal is employed, it ought either to be *fresh made, or heated again in close vessels, so as to expel the water* which it greedily attracts from the air.

It is to be observed here, that the practice of pitching pales, &c. is both incommodious, and inefficacious, as pitch is so liable to be melted by the heat of the sun.

DCCCCLXXXIX.

METHOD OF SEASONING MAHOGANY.

This method, which was discovered by Mr. Callender, and for which he was rewarded by the Society of Arts, is both simple and efficacious.

Having provided a steam-tight wooden box, capable of holding conveniently such pieces of Mahogany as are fit for Chairs, &c. he adapts to it a pipe from a boiler, by means of which he fills the box (after the Mahogany has been put into it,) with Steam, the temperature of which is about equal to that of boiling water. The time required for wood, an inch and a half thick, is about two hours; and pieces of this thickness are stated to become sufficiently dry to work, after being placed in a warm room or workshop for twenty-four hours. By this treatment, the wood is something improved in its general colour; and those blemishes, which are technically called *green veins*, are entirely removed. The eggs, or larvæ, also, of any insect, which may be contained in the wood, will be destroyed by the heat of the Steam.

Observations. Two very important advantages are said to result from Mr. Callender's process. In the first place, *a considerable part of the capital,* which is vested in wood lying to season during many months, *may be saved.* And secondly, as none of the small wood, from two to six inches thick, is ever seasoned, according to the usual course of trade, chairs, ballustrades, and similar articles, which are usually made of such wood, must necessarily be very subject to warp, which inconvenience is prevented by adopting the expeditious mode of seasoning above described.

DCCCCXC.

MODE OF PAINTING SAIL-CLOTH, &c.

So as to be pliant, durable, and impervious to Water.

This process which is extracted from the *Transactions of* *the Society of Arts*, is now universally practised in the public Dock-yards.

The Paint usually laid upon Canvas, hardens to such a degree as to crack, and eventually to break the Canvass, which renders it unserviceable in a short time; but the Canvass painted in the new manner is so superior, that all Canvass used in the navy is thus prepared; and a saving of a guinea is made in every one hundred square yards of Canvass so painted.

The old mode of painting Canvass, was to wet the Canvass and prime it with Spanish brown; then to give it a second coat of a Chocolate colour, made by mixing Spanish brown and black Paint; and lastly, to finish it with black.

The new method is to grind 96 lbs. of English Ochre with boiled Oil, and to add 16 lbs. of black Paint, which mixture forms an indifferent black. A pound of *yellow soap* dissolved in six pints of water over the fire, is mixed, while hot, with the Paint. This composition is then laid upon the Canvass (without being wetted, as in the usual way,) as stiff as can conveniently be done with the brush, so as to form a smooth surface; the next day, or, still better, on the second day, a second coat of Ochre and black (without any, or but a very small portion of Soap) is laid on, and allowing this coat an intermediate day for drying, the Canvass is then finished with black Paint as usual. Three days being then allowed for it to dry and harden, it does not stick together when taken down, and folded in cloths containing 60 or 70 yards each; and Canvass finished entirely with the composition, leaving it to dry one day between each coat, will not stick together, if laid in quantities.

Observations. It has been ascertained from actual trials, that the solution of yellow soap is a preservative to red, yellow, and black paints, when ground in oil and put into casks, as they acquire no improper hardness, and dry in a remarkable manner when laid on with the brush, without the use of the usual drying articles.

It is surprising that the adoption of soap, which is so well known to be miscible with oily substances, or at least the alkali of which it is composed, has not already been brought into use in the composition of oil colours.

DCCCCXCI.

VARNISH FOR BOOTS AND SHOES,

By which they are rendered impervious to Water.

The following method of effecting this useful purpose is related in Sir John Hawkins's edition of Isaac Walton's complete Angler:—Take a pint of Linseed Oil, with half a pound of Mutton Suet, six or eight ounces of Bees' Wax, and a small piece of Rosin. Boil all this in a pipkin together; and let it cool till it be milk-warm. Then with a hair-brush, lay it on new boots, or shoes; but it is best that this Varnish be laid on the Leather, before the boots are made. The boots should also be brushed over with it, after they come from the maker. If old boots or shoes are to be varnished, the mixture is to be laid on, when the Leather is perfectly *dry*.

DCCCCXCII.

METHOD OF VARNISHING HATS,

So as to be impervious to Water.

A patent has lately been taken out by Messrs. Pritchard and Franks, for the following mode of rendering Hats impervious to water. It must be premised, that the following list of ingredients is so *redundant*, as not to admit of application, either with success, or with advantage as to economy. It is therefore necessary to mark in *Italics*, such ingredients as may with propriety be omitted in the composition; bearing in mind at the same time, that the quantity of Alcohol is also to be reduced.

The shell of the Hat is to be prepared of the usual materials, and dyed and formed into shape in the usual way. When perfectly dry, it is to be stiffened with the following composition, worked upon the inner surface:—One pound of *Gum Kino*, eight ounces of Gum Elemi, three pounds of *Gum Olibanum*, three pounds of Gum Copal, two pounds of *Gum Juniper*, one pound of *Gum Ladanum*, one pound of Gum Mastic, ten pounds of Shell-lac, and eight ounces of Frankinscense: these are pounded small and mixed together; three gallons of Alcohol are then placed in an earthen vessel, to receive the pounded Gums; the vessel is then to be frequently agitated.

When the Gums are sufficiently dissolved by this process, the patentees add to the mixture, one pint of liquid Ammonia, and one ounce of Oil of Lavender, with a pound of *Gum Myrrh and Gum Opoponax, dissolved in three pints of Spirit of Wine.* The whole of the ingredients being perfectly incorporated, and free from lumps, constitute the water-proof mixture with which the shell of the Hat is stiffened.

When the shell has been dyed, shaped, and rendered perfectly dry, its inner surface and the under side of the brim are varnished with this composition by means of a brush. The hat is then to be placed in a warm drying-room until hard. This process is repeated several times, taking care that the varnish does not penetrate through the shell, so as to appear on the outer side. To allow the perspiration of the head to evaporate, small holes are to be pierced through the crown of the hat from the inside outward; and the nap of silk, beaver, or other fur, is to be laid on by the finisher in the usual way; that on the under side of the brim, which has been prepared as above, is to be attached with copal varnish.

DCCCCXCIII.

EXCELLENT VARNISH FOR SILKS, &c.

To one quart of cold-drawn Linseed Oil, poured off from the lees (produced on the addition of unslacked Lime, on which the Oil had stood eight or ten days at the least, in order to communicate a drying quality,—or brown Umber, burnt and pounded, which will have the like effect,) add half an ounce of Litharge; boil them for half an hour, then add half an ounce of the Copal varnish. While the ingredients are on the fire, in a copper vessel, put in one ounce of Chios Turpentine or common Resin, and a few drops of Neatsfoot Oil, and stir the whole with a knife; when cool, it is ready for use. The Neatsfoot Oil prevents the varnish from being sticky or adhesive, and may be put into the Linseed Oil at the same time with the Lime, or burnt Umber. Resin or Chios Turpentine may be added till the varnish has attained the desired thickness.

Observation. The longer the raw linseed oil remains on the unslacked lime or umber, the sooner will the oil dry after it is used; if some months, so much the better: such varnish will set, that is to say, not run, but keep its place on the silk in four hours; the silk may then be turned and varnished on the other side.

DCCCCXCIV.

PLIABLE VARNISH FOR UMBRELLAS, BALLOONS, &c.

Take any quantity of Caoutchouc, as ten or twelve ounces, cut it into small bits with a pair of scissors, and put a strong iron ladle (such as painters, plumbers, or glaziers melt their lead in,) over a common pit-coal or other fire; which must be gentle, glowing, and without smoke. When the ladle is hot put a single bit into it: if black smoke issues, it will presently flame and disappear, or it will evaporate without flame: the ladle is then too hot. When the ladle is less hot, put in a second bit, which will produce a white smoke; this white smoke will continue during the operation, and evaporate the Caoutchouc; therefore no time is to be lost, but little bits are to be put in, a few at a time, till the whole are melted; it should be continually and gently stirred with an iron or brass spoon. The instant the smoke changes from white to black, take off the ladle, or the whole will break out into a violent flame, or be spoiled, or lost. Care must be taken that no water be added, a few drops only of which, would, on account of its expansibility, make it boil over furiously and with great noise; at this period of the process, two pounds or one quart of the best drying Oil are to be put into the melted Caoutchouc and stirred till hot, and the whole poured into a glazed vessel through a coarse gauze, or wire sieve. When settled and clear, which will be in a few minutes, it is fit for use, either hot or cold.

Observations. The silk should be always stretched horizontally by pins or tenter-hooks on frames: (the greater they are in length the better,) and the varnish poured on *cold in hot weather* and *hot in cold weather.* It is perhaps best, always to lay it on when cold. The art of laying it on properly, consists in making no intestine motion in the varnish, which would create minute bubbles, therefore brushes of every kind are improper, as each bubble breaks in drying, and forms a small hole, through which the air will transpire

This varnish is pliant, unadhesive, and unalterable by weather, whilst it is perfectly impervious to air.

DCCCCXCV.

VARNISH USED FOR INDIAN SHIELDS.

Shields made at Silhet, in Bengal, are noted throughout India, for the *lustre and durability of the black varnish* with which they are covered; Silhet shields constitute therefore no inconsiderable article of traffic, being in request among natives who carry arms and retain the ancient predilection for the scimitar and buckler. The Varnish is composed of the expressed juice of the marking nut, *Semecarpus Anacardium*, and that of another kindred fruit, *Holigarna Longifolia.*

The shell of the *Semecarpus Anacardium* contains between its integuments, numerous cells, filled with a black, acrid, resinous juice; which likewise is found, though less abundantly, in the wood of the tree. It is commonly employed as an indelible ink, to mark all sorts of cotton cloth. The colour is fixed with quick lime. The cortical part of the fruit of *Holigarna Longifolia* likewise contains between its laminæ, numerous cells, filled with a black, thick, acrid fluid. The natives of Malabar, (in which country, as well as in the eastern parts of Bengal, the tree is indigenous,) extract by incision its very acrid juice, with which they varnish targets.

Both are combined for the same purpose, by the artizans of Silhet. The juices are resinous, being soluble in Alcohol, and not at all so in Water. They may be dissolved in fixed Oils, and in dilute Alkali.

To prepare the Varnish according to the method practised in Silhet, the nuts of the *Semecarpus Anacardium*, and the berries of the *Holigarna Longifolia*, having been steeped for a month in clear Water, are cut transversely, and pressed in a mill. The expressed juice of each is kept for several months, taking off the scum from time to time. Afterwards the liquor is decanted, and two parts of the one are added to one part of the other, to be used as Varnish. Other proportions of ingredients are sometimes employed; but in all, the resinous juice of the *Semecarpus* predominates. The Varnish is laid on like paint, and when dry, is polished by rubbing it with an agate, or smooth pebble. This Varnish also prevents destruction of Wood, &c, by the *White Ant.*

DCCCCXCVI.

FRENCH VARNISH, FOR CABINETS, &c.

Take Shell Lac, three parts; Gum Mastich, one part; Gum Sandarach, one part; Alcohol, forty parts. The Mastich and Sandarach must first be dissolved in the Alcohol, and then the Shell Lac: this may be done either by putting them into a bottle loosely corked, and placing it in a vessel of Water, heated below the boiling point of Alcohol, until the solution is effected; or by putting the ingredients into a clean Florence oil-flask, (the neck of which is partially closed by a cork, having a narrow slit along it,) it is to be heated over a spirit-lamp. The Alcohol which escapes during the process must be replaced by an equal weight of it, after the operation is over; as it is desirable that the Varnish should consist of the proportions given, in order to be good. The solution may be poured off for use, from the impurities which remain, but it must not be filtered, as that operation would deprive the Lac of some of its qualities.

Observation. In cases where a greater degree of hardness in the varnish is desirable, and its colour is but a secondary consideration, one part of shell lac with eight parts of alcohol, is to be preferred.

DCCCCXCVII.

COPAL VARNISH.

Reduce to powder an ounce of pure Carbonate of Potass, and then lay it before the fire, till it becomes hot and dry. In this state, put it into a pint of Alcohol, or Oil of Turpentine. All the watery particles contained in the Oil or Spirits, will be absorbed by the Alkali; and the Alcohol, or Turpentine, will thus become pure, or highly rectified. This process is called *Alkalizing* these solvents. Now put the Turpentine or Spirits into a vessel with two ounces of clear dry Copal, finely pounded and sifted: place the vessel in warm Water; the Copal will be soon dissolved.

Observations. This varnish, which is principally applied to wood, paste-board, and prints, is to be diluted by a little warm oil of turpentine, before it is used.

If the spirits of turpentine be alkalized when the copal is dissolving, a little spirits of wine should be added; and if the spirits of wine be alkalized when the copal is dissolving, a little spirits of turpentine should be added: the sediment of the varnish will dry on the silk in a few hours; the thicker the varnish, the sooner it dries.

DCCCCXCVIII.

VARNISH FOR OIL PAINTINGS.

Mix six ounces of pure Mastich Gum with the same quantity of pounded Glass, and introduce the compound into a bottle containing a pint of Oil of Turpentine; (treated with Alkali as above), now add half an ounce of Camphor bruised in a mortar. When the Mastich is dissolved, put in an ounce of Venice Turpentine, and agitate the whole till the Turpentine be perfectly dissolved.

Observations. When to be used, this varnish must be gently poured off the glass sediment at the bottom of the bottle; or it may be filtered through muslin. The intention of using ground glass, is to present a greater surface of mastich, to the solvent, by throwing the particles as much apart as possible.

DCCCCXCIX.

LACQUER, OR VARNISH FOR TIN WARE.

Put three ounces of Seed Lac, two drams of the substance known by the name of Dragon's blood, *(Sanguis Draconis)* and one ounce of Turmeric powder, into a pint of well rectified spirits. Let the whole remain for fourteen days, but during that time, agitate the bottle once a day at least. When properly combined, strain the liquid through muslin.

Observation. This varnish is called a *lacquer;* it is brushed over tin ware which is intended to imitate brass.

M.

Lacquer for Brass Work.

Put into a pint of Alcohol, an ounce of Turmeric powder, two drams of Arnotto, and two drams of Saffron; agitate during seven days, and filter into a clean bottle. Now add three ounces of clean Seed-lac, and agitate the bottle every day for fourteen days. The mixture will now be that known as Lacquer for Brass.

Observations. When the lacquer is used, the pieces of brass, if large, are to be first warmed (so as to heat the hand) and the varnish is to be applied by a brush: the smaller pieces may be dipped in the varnish, and then drained by holding them for a minute over the bottle. This varnish when applied to rails for desks, &c., has a most beautiful appearance, being like burnished gold.

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* By some mistake this has, in a few copies, been placed after Experiment 523.

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